THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 58 Thursday, March 17, 1938 No. 1126

PUBLISHED WEEKLY

Subscription Terms : 17s. 6d. per annum.
Foreign and Colonial : 20s. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL
49, WELLINGTON STREET, LONDON, W.C.2

Telegraphic Address : "Zacatecas, Rand, London."
Telephone : Temple Bar 3951 (5 lines).

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF

The Institute of British Foundrymen

The Institute of Vitreous Enamellers

The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

Institute of British Foundrymen

PRESIDENT : 1937-38

C. W. Bigg, "Selworthy," Burley Lane, Quarndon near Derby.

LIST OF SECRETARIES—

General Secretary : T. Makemson, Saint John Street Chambers, Deansgate, Manchester, 3. London Office : 49, Wellington Street, London, W.C.2.

Birmingham, Coventry and West Midlands : A. A. Timmins, A.I.C., 21-23, St. Paul's Square, Birmingham, 3.

East Midlands : B. Gale, "Parkdale," Boulton Lane, Alvaston, Derby.

Lancashire : J. E. Cooke, 7, Warren Drive, Swinton, Manchester.

London : R. Causebrooke, 333, Eton Road, Ilford, Essex.

Middlesbrough : G. P. Kirk, North-Eastern Iron Refining Company, Limited, Stillington, Stockton-on-Tees.

Newcastle-upon-Tyne : C. Lashly, Sir W. G. Armstrong, Whitworth & Company (Ironfounders), Limited, Close Works, Gateshead-on-Tyne.

Scottish : J. Bell, 60, St. Enoch Square, Glasgow.

Sheffield : T. R. Walker, M.A., "The Priory," Oughtibridge, near Sheffield.

Wales and Monmouth : J. J. McClelland, 12, Clifton Place, Newport, Mon.

West Riding of Yorkshire : S. W. Wise, 110, Pullan Avenue, Eccleshill, Bradford.

South Africa : F. C. Williams, Magor House (Fifth Floor), 74, Fox Street, Johannesburg.

Bristol : A. Hares, Park Crescent, 648, Stapleton Road, Bristol, 5.

Burnley : W. Haworth, 37, Westbourne Avenue, Burnley, Lancs.

East Anglian : J. L. Francis, 12, Glenhurst Avenue, Colchester Road, Ipswich.

Falkirk : T. R. Goodwin, "Viewfield," Falkirk Road, Bonnybridge, Scotland.

Lincoln : E. R. Walter, M.Sc., The Technical College, Lincoln.

The Institute of Vitreous Enamellers

President : Sir Harold Hartley, F.R.S., Euston Station, London, W.C.1.

Chairman : W. H. Whittle, W. H. Whittle, Limited, Eccles, near Manchester.

Hon. Secretary : Miss E. Christine Elliot, 49, Wellington Street, Strand, London, W.C.2.

Foundry Trades' Equipment and Supplies Association

President : A. C. Turner, Russell House, Adelphi, London, W.C.2.

Secretary : K. W. Bridges, Grand Buildings, Trafalgar Square, London, W.C.2.

Welsh Engineers' and Founders' Association

President : W. E. Clement, Morfa Foundry, New Dock, Llanelly.

Secretary : J. D. D. Davis, 9, Royal Metal Exchange, Swansea.

BRITISH CAST IRON RESEARCH ASSOCIATION

The Registered Office and Laboratories of the B.C.I.R.A. are :—
21-23, ST. PAUL'S SQUARE, BIRMINGHAM
Telephone: Colmore 4274-4275. Telegrams: CIRA

The B.C.I.R.A. Scottish Laboratories are :—
Foundry Technical Institute, Meek's Road, Falkirk
Telephone: 332

Contents

	PAGE
The Metallurgical Anschluss	231
Physics and Chemistry in Metallurgy	231
Surtees Memorial Awards	232
International Engineering Congress	232
A New Source of Steel Moulding Boxes	232
Random Shots	232
Production of "Pressure-Tight" Castings in Grey Iron and Its Alloys	233
A Novel Development in Melting Practice	235
Moulding a Motor Spider	236
Bronze-Welding of Cast-Iron Pipe	237
The Iron and Steel Institute	238
Some Aspects of the Casting of Commercial Ingots	239
Refined Pig-Iron, Chilled Grit and Pre-Cast Cement	243
Composition and Microstructure of Ancient Iron Castings	244
Foundry Trades' Equipment and Supplies Association	246
Pig-Iron and Steel Output	246
The Week's News in Brief	248
Trade Talk	248
Personal	248
Obituary	248
Company Reports	248
Contracts Open	248
Forthcoming Events	248
Raw Material Markets	250
New Zealand Iron and Steel Industry	250

The Metallurgical Anschluss

An ideal which has been permeating the minds of some of the leaders of metallurgical thought in Great Britain has found concrete expression in the unification of certain well-defined interests of the Iron and Steel Institute and the Institute of Metals. This is now *un fait accompli*, and the best that can be done is to tender to the new union our best wishes for its future success. A matter of more import, however, is the underlying ideal which, briefly stated, has for its object intense co-operation between all the metallurgical and allied institutes, including those devoted to research. Some dreamers even include engineering and the pure sciences. If we were referring to industrial conditions, we should designate the operation as "horizontal trustification" and *ab initio* its worth would be evaluated against "vertical trustification." Logically, there are good grounds why, when referring to matters metallurgical, a similar line of thought should be examined with a view to ascertaining whether better prospects of progress are not revealed. Taking the foundry industry as the one with which we are obviously the most familiar, the case for vertical rather than horizontal trustification seems to commend itself on the following grounds. Taking for granted that a technical institute is fundamentally a means for propagating technology amongst a maximum number of people in the industry for the particular benefit of the individual and so leading to general progress, and is not just a medium for the publication of research Papers, then this, surely, is best effected by the closest co-operation with the employers' federations, the research associations, the standardising bodies, the educational authorities, allied institutes and even the trade unions. By this means, every phase of activity, provided that local activities are well catered for (as is the case with the Institute of British Foundrymen), is brought right to the door of each member of the industry. The welding of the metallurgical institutes into one huge consortium, with its plethora of symposiums, means that only the élite of the metallurgical world will participate to any great extent. The advantages of centralised buildings and a magnificent technical library do not outweigh the benefits to be derived from activities emanating from a smaller democratic body, which is a true cross-sectional concept of the whole of one industry.

Physics and Chemistry in Metallurgy

In his Presidential Address to the Institute of Metals, published in our last issue, Dr. Desch points out that metallurgy is based on physics and chemistry, and that its connection with chemistry is much the older. Within quite recent times it looked as if physics, in the magnificent onward sweep of development of atomic physics and in other advances, might oust chemistry or at least compel it to take a very secondary place as a means of securing information about the metals. The advances based on the spectroscope are good examples, but best of all are the brilliant developments in the knowledge of crystal structure due to the use of X-rays. This has already gone so far that men trained in more classical physics are apt to be disconcerted by the way in which their juniors interpret everything in terms of the space lattice. Yet in spite of all this, chemistry seems to be holding its own, and, in admitting this, we do not need to consider metallographic etching as other than part of a purely physical method. For example, an enormous amount of activity is being shown in all industrial countries about non-metallic inclusions in metals, but the methods adopted are largely chemical, whether they be the vacuum fusion method of determining oxygen, or the halogen methods of getting rid of the metal and leaving the non-metallic residue. As Dr. Desch indicates, there is a growing interest also in micro-chemical methods by means of which analyses may be made of quantities of material which do not amount to much more than traces. The difficulty of both physical and chemical methods of this highly specialised character is that not more than a few institutions or works in the country are likely to have the resources in men and material to be able to practise them. We may, however, take it that of the main channels open to us for obtaining information about the metals, both chemical and physical methods are showing rather greater progress than mechanical testing, which will doubtless link up with developments in knowledge of crystal structure.

Surtees Memorial Awards

SCOTTISH PRIZE-GIVING

The presentation of awards to successful candidates in the Surtees Memorial Competition was made at a meeting of the Scottish Branch of the Institute of British Foundrymen in Glasgow last Saturday. Mr. R. M. Allardyce, O.B.E. (Director of Education for Glasgow), performed the prize-giving.

Introducing Mr. Allardyce, MR. E. J. ROSS (Branch-President) said that there had been a great number of entrants in the Junior Section of the competition, and this was a matter of great satisfaction, because this section was confined to young men, serving an apprenticeship in moulding or patternmaking, who presumably would be the foundrymen of the future. About 80 per cent. of the entrants were attending the classes in foundrywork at the Stowe College, the direction of which formed part of Mr. Allardyce's activities. Lads who attended these classes must gain a great advantage over those who did not, inasmuch as they became better equipped with knowledge of their craft and enhanced their chances of advancement. Mr. Ross then called on Mr. Allardyce to present the prizes to the successful candidates.

MR. ALLARDYCE handed medals and prizes to the following:—

SENIOR GRADE.—*Gold Medal*, A. M. Campbell (G. & J. Weir, Limited).

JUNIOR GRADE.—*Silver Medal and 1st Prize*, John Allen (G. & J. Weir, Limited). *2nd Prize*, Thomas Hunter (Singer Company). *3rd Prize*, Wm. G. Murray (Lion Foundry Company). *4th Prize*, John Robb (D. & J. Tullis, Limited).

MR. ALLARDYCE congratulated the winners on having accomplished something well worth doing, and doing something which required much to accomplish. Whether a prize was obtained or not, the candidates had obtained valuable experience and practice which would be of assistance to them later in life. To-day, with the rapid developments in science and the advancement of applications of science to industry, it became somewhat difficult to keep pace with changes in practice and to put down on paper all the details of industrial processes in a clear and concise manner, so that a person unacquainted with a process could understand it. This led back to discussions which had taken place from time to time as to what should be taught in continuation classes. It was most important that every young man should get as much practice as possible in writing English, not in the fine literary style, but of writing a plain simple description. So long as examinations were to be one of the few ways in which a young man could be tested, they had to see that the young men in continuation schools could express themselves clearly in plain simple language.

He was proud to have had the Stowe College under his care, and they in Glasgow were proud of the college. Its activities were known outside the city. He had recently been talking with colleagues from England, and found that they knew all about the college and what it was doing through the Institute of British Foundrymen in Glasgow. All those who had won prizes in this competition, and all those who had not, had done something for their own advancement, the advancement of the industry and to make the world a better place. He urged them to continue their efforts.

Vote of Thanks

MR. N. MCMANUS, in proposing a vote of thanks to Mr. Allardyce for coming to the meeting and making the presentations, said they were pleased to note the great interest he took in the Stowe College. His address would inspire more of the young men to enter the next competition. Whether they gained prizes or not they obtained a lot of benefit from having to study the problems and collect the necessary information. He hoped that candidates from more firms would be encouraged to come forward next time. Since 1924, when the competition began, eight gold medals had been awarded, and five of them had been won by young men from his firm. He hoped in future competition would be stronger.

Annual General Meeting

The meeting then resolved itself into the annual general meeting of the Branch.

The SECRETARY (Mr. John Bell) submitted the annual report of council, which showed that the membership during 1937 had remained exactly the same as in 1936, and that the value of arrears of subscriptions was rather less than in the previous year.

On the motion of MR. H. W. WINTERTON, seconded by MR. JAMES AFFLECK, the report and balance sheet were adopted.

The BRANCH-PRESIDENT thanked the retiring members of council for the services they had rendered during their term of office, and expressed the hope that they would continue their interest in the work of the Institute in the future as in the past.

The election of officers for next session resulted as follows:—

President.—Mr. R. Ballantine (Fullwood Foundry Company).

Senior Vice-President.—Mr. N. A. W. Erskine (Camelon Iron Company).

Junior Vice-President.—Mr. A. L. Mortimer (Argus Foundry Company, Limited).

Members of Council.—Mr. B. MacDougall, Mr. R. D. Lawrie and Mr. W. Braidwood.

Representatives to General Council.—Dr. J. W. Donaldson, Mr. N. McManus and Mr. T. Shanks.

Representatives to Technical Committee.—Mr. J. Arnott and Dr. J. W. Donaldson.

Hon. Secretary.—MR. John Bell.

MR. JOHN CAMERON, JUN., then read a Paper on "The Fettling Shop."

International Engineering Congress

As already announced, an International Engineering Congress is to be held in Glasgow from June 21 to 24. At the technical sessions, to be held at the Empire Exhibition, an opening address will be given by the President, the Rt. Hon. Lord Weir, P.C., G.C.B., followed by a series of fifteen addresses by outstanding British and foreign engineers.

In addition to a number of social events there will be official visits to numerous works including the following: John Brown & Company, Limited, Wm. Beardmore & Company, Limited, Wm. Dixon, Limited, Harland & Wolff, Limited, Mavor & Coulson, Limited, Babcock & Wilcox, Limited, Colvilles, Limited, and G. & J. Weir, Limited. All-day groups of visits will include: Bruce, Peebles & Company, Limited; Bruntons (Musselburgh), Limited, Glenfield & Kennedy, Limited, and Bairds & Dalmellington, Limited.

A New Source of Steel Moulding Boxes

The Bilston Stove & Steel Truck Company, Limited, of Hare Street, Bilston, Staffs, have recently installed special plant for the manufacture of steel moulding boxes from mild-steel chequer plate. Sections are sheared from standard plates, thus eliminating the necessity of resorting to numerous rolled sections. The sections are pressed and electrically welded, as are the lugs and handles, but the latter are omitted from the smaller boxes as the lugs have been so designed as to form a proper and convenient means for handling.

The boxes are accurately drilled and reamered from jigs, and where they are to be used for machine moulding the joints are ground.

Random Shots

It was a source of satisfaction to many that the Institute of Metals reverted to the inclusion of a dance following the annual banquet. Yet, by the irony of fate, the speeches were so snappy and to the point that they would have served as a model for a full-length toast list. Lord Dudley was in particularly good form, and "Marksman" thought his reference to Dector Dosch and Mr. Scaw Shott well fitted the atmosphere which earlier speakers had engendered. Lord Riverdale's experiments at Niagara Falls with electric furnaces in 1892 (or was it 1893?) antedated the commercial birth of this industry, though Pepys—not the diarist—in 1815 invented the resistance furnace. The date for commercial steel melting is about 1898, when Kjellin, Stassano and Héroult became active. In aluminium, however, Héroult had been active since 1887, whilst calcium carbide dates from 1894.

* * *

Talking about electric furnaces, the story can now be told of a firm building electric furnaces who received an order during the war for one to be erected at Bilbao. Not wishing to disclose the fact that they had not made more than a dozen or so, they thought it desirable to impress on the Spaniards their great experience, and promptly labelled the new order Job No. 100. This greatly amused the customers, as it is this number which is normally assigned by small hotels in Spain to the lavatory!

* * *

When rumours get abroad which later prove to be true, as was the case in connection with the impending removal of the Iron and Steel Institute and the Institute of Metals to Grosvenor Gardens, one usually imagines a leakage in High Places, but this is not always the case. One individual swears that it was the postman who first told him of the impending change!

* * *

And when one comes to think of it, the postman with a lively brain could weave a pretty romance of the lives lived on the other side of those letter boxes through which he drops the daily post. He can soon spot the man with an incurable passion for seed catalogues, not to mention the man who never pays his rates, gas and electricity bills until the second application comes in. A sensitive postman must almost wince as he puts through those second applications, and envelopes marked "Income Tax—Private" must be a constant source of pain to him. To counterbalance this, "Marksman" remembers particularly one morning when the postman had to knock at the door because he had so many small parcels to deliver. "Wish the little missy a very happy birthday," said he, with a beam of pleasure, because he had guessed aright and was for once the purveyor of pleasure instead of pain.

* * *

Amongst the bright suggestions for the Empire Exhibition at Glasgow is that attractive trips down the Clyde should be arranged, and one cartoonist evidently thinks that prosaic river steamers should be replaced by gondolas on Venetian lines, with bra' Scotties acting as gondoliers. It is an idea which seems as if it might materialise, for has not Mr. Chamberlain already decided to open conversations with Italy? Lord Halifax should come back with the real "low-down" on Venetian gondolas.

"MARKSMAN."

SIR HAROLD CARPENTER enjoys the unique distinction of having successively occupied the presidential chair of the three Institutes covering the field of metallurgy, namely, the Iron and Steel Institute, the Institute of Metals, and the Institution of Mining and Metallurgy. This fact was commented upon by Dr. C. H. Desch in his presidential address last week to the Institute of Metals.

Production of "Pressure-Tight" Castings in Grey Iron and Its Alloys*

By A. E. McRAE SMITH, M.A.

The field covered by the phrase "pressure-tight" castings is an extremely wide one, and when thinking around it one immediately begins to discriminate. What is meant by the phrase, and just exactly what range of castings does it include? It would be folly to attempt to discuss, in a short descriptive Paper such as this is intended to be, the whole range of castings which might logically be classified as castings to withstand liquids and gases under pressure.

The types which leap to one's mind vary from simple rainwater goods, tanks, troughs, and simple liquid containers or components transmitting liquids and gases under the lowest of pressures, to the other extremity, where complicated and intricate forms are subjected to very high stresses and pressures. It is intended to deal only with castings which are required to withstand medium and high pressures, such as cylinders for steam, air and other gases; hydraulic castings and castings to withstand oils and other liquids under difficult conditions.

As evolution and progress proceed in the mechanical world to-day, the foundryman is called upon to exercise his skill and ingenuity to meet increasingly higher requirements not only in regard to increased physical properties in the material he is called upon to cast, but also, and this is really more important, to cast shapes and forms which become increasingly more complicated.

As an example this is seen strikingly in the realm of the internal-combustion engine, whether the fuel be petrol or heavy fuel oil. It is proposed in this Paper to bring forward a few aspects of the metallurgical and practical difficulties which arise in the production of so-called "pressure-tight" castings.

The first steps to be considered, once any particular design of casting has been originated in the mind of a designer, or group of designers, and been duly transferred to geometrical proportions in a drawing, consist chiefly in deciding the necessary physical properties required in the material. Will it be forged, fabricated, cast to shape, or machined from the solid?; will its nature be based on any of the following groups:—Steels; cast irons; copper and similar non-ferrous alloys; aluminium alloys, or the like?

Having decided that the best material for the particular hypothetical component is grey cast iron or alternatively an alloy cast iron, then one must determine whether it is a practical proposition to make a casting exactly as laid down by the designers or whether alterations are required to make the component "castable."

At this stage, co-operation between designers and foundry executives should help to pave the way for a thoroughly satisfactory job, in the particular type of cast iron decided upon. Details, such as reasonable equality of section, accessibility for core extraction, machining allowances, degree of ease of machinability, correctness to size and shape and tolerances as to dimensional sizes and many others must be mutually agreed.

Having decided on the two initial essentials, namely, kind of material to be used and exact details of casting shape, it is now up to the foundryman to produce, from the chosen material, a casting which will be not only pressure-tight but can also be machined with the greatest facility for the job in hand, and be produced in the most economical manner. Also it is most important that the castings can be repeated from day to day, from casting to casting or from batch to batch, without departing in any marked degree from the optimum qualities sought; and by quality is meant not only a constant composition, which will not vary beyond narrow limits, but also the physical properties of each individual casting, including machinability and freedom from defects.

For the purpose of this brief summary it will be convenient to discuss the general problems likely to be encountered under two main groups:—

(1) *Details and problems relating to foundry practice*, to include moulding methods, moulding materials, distribution and types of runners to be used; methods of dealing with solidification shrinkage, or so-called feeding methods.

(2) *Metallurgical problems*, to include types of grey irons and alloy irons to be used; methods of melting, melting control and details related thereto.

FOUNDRY PRACTICE

The moulding method to be adopted for any particular casting must depend entirely on the principle that the best possible casting is to be produced for the least possible expenditure of materials and labour. Whether the casting be made by loam, dry or green sand methods, by mechanical, semi-mechanical or non-mechanical means, and all such details, will, of necessity, depend on type, the number off, finish and quality required and similar circumstances; in the selection of production methods, regularity of quality should take premier place.

In the same way, within reasonable limits, the selection of moulding materials to attain this ever to be strived at uniformity of results will depend entirely on economic conditions, which will give the desired casting, in the cheapest possible way, in any one particular foundry. These materials will vary greatly, not only from one district to another, but also between individual foundries, on account of the quality to price ratio governing the choice of sands, etc., and the abundance or scarcity of highly-skilled labour.

Therefore, it is not intended to discuss such interesting features as synthetic sands *versus* naturally-bonded sands, or naturally-bonded core materials as compared with silica sand, oil-bond mixtures and the like. It will be sufficient to stress the point that, in the production of pressure-tight castings, it is always essential that the moulding practice be of such a standard as to produce a mould where strength and permeability of the mould structure, refractoriness of the mould face, correctness of shape, allowances for contraction, contractability of the core structures, etc., will give, no matter how high the temperature of the metal used to fill the moulds, a casting free from defects arising from weaknesses in the mould itself.

What is extremely important, however, is the choice of casting position, distribution, shape and size of runners, correlated with rate of filling the mould and method of feeding and type of feeders to be used. By casting position, one means to signify whether the mould will be cast to give a horizontal or vertical position to the casting as the mould is filled.

This is a question which must be decided prior to the pattern or other moulding tackle being constructed. Whichever way is found to be most suitable for the job concerned, it is not only necessary to decide between horizontal and vertical casting. It is often much more important carefully to consider which will be the top or bottom of the casting. This is of vital importance, and apart from considerations arising from the location of the more important machined faces, it should be made a hard and fast rule that, irrespective of size, the mould should be so arranged that there is a controlled gradation of solidification from liquid to solid. This means that, other things being equal, the heavier masses should be at a higher elevation in the mould compared with the parts of normal sectional thickness.

The Case of a Flanged Liner

For instance, if the component to be made is a plain liner, to take a simple example, with a flange at one end, because of this flange having a heavier wall thickness than the body of the liner, the safest policy is to cast the liner flange upwards and supply a suitable feeding head above the flange, to ensure that the flange is free from any porosity due to solidification shrinkage. Only in this way is it possible to obtain the necessary differential solidification from the bottom to the top of the casting and to ensure that the unfeedable shrinkage defect will be located in the feeding head and not in the casting itself.

Valve Body Castings

For another simple example one might cite the case of heavily flanged high-pressure valve bodies, such as are used in liquid or gaseous ammonia pipe lines. These invariably exhibit greatly varying sectional thickness and a safety-first method of ensuring freedom from porosity is to put heavy bulbous feeders on top of the flanges, so as to ensure complete soundness in the body of the casting, as well as the flanges. That is another case of differential and graduated solidification.

Of course, as will be discussed later, a reasonably suitable metal mixture must be adopted for all castings to withstand high pressure, but the selection of correct self-feeding methods will allow a much greater latitude in the selection of the composition.

Runners and Freezing Range

In the same way, the distribution, size and shape of runners to any mould must be determined, by careful study, for each individual casting, largely irrespective of metal composition. Compositions with a limited freezing range will require larger or at least a wider distribution of runners compared with normal medium-carbon grey irons, but apart from this qualification, every attempt should be made to get the metal to enter a mould in such a way that it will be equally and reasonably rapidly distributed. In this way so-called hot spots due to isolated runners will be avoided.

Far too often, even experienced foundrymen are content to allow moulders to cut runners and risers in a haphazard manner. The size and shape of the moulding box is often an excuse for faulty and inadequate runners. It is impossible to dogmatise on the best methods of running any particular casting, and there has always been a great deal of controversy between the exponents of top and bottom running of cylindrical castings for example. Some favour top running, others bottom running, and sometimes a combination of both.

Top Pouring of Cylinders Advocated

In the author's opinion, wherever possible, cylindrical castings such as liners, compressor cylinders, hydraulic cylinders and similar castings should be poured by means of well distributed and suitably proportioned top runners. By this means the rising surface of the metal in the mould is continuously supplied with hot metal. Apart from helping to keep the casting clean, and to ensure minute particles of mould *débris* being brought to the top, out of harm's

* A Paper read before the London Branch of the Institute of British Foundrymen, Dr. A. B. Everest presiding.

way, this method ensures that the casting will commence to solidify in the desired part. Conversely, by bottom running such castings, the bottom end is being fed with hot metal until the mould is full, and consequently the correct sequence of solidification is upset.

In certain circumstances a combination of top and bottom runners is expedient, but more often than not it is a makeshift, the true reason for its adoption being lack of confidence in the quality of the mould structure.

No matter what method or speed of running has been standardised for any particular casting, after having been found successful, it should not be altered in even the most minute detail, other things such as type of metal being constant. This remark also applies to self-feeding heads, risers, or lack of risers, and particularly in the case of hand-moulded production. With machine and plate moulding the question does not arise to any great extent, but it is common knowledge how individual moulders are prone to make intentional as well as accidental changes without any good reason.

In making pressure-tight castings, this failure to secure complete constancy of method is the cause of many failures. The anchorage of cores is also a detail which is not given sufficient attention. Here, again, individual moulders are often inclined to take the easiest or shortest way and use studs and chaplets where their use could be readily avoided. Chaplets should never be used in pressure-tight castings unless it is definitely impossible to anchor a core without their use.

From the above remarks it will be seen that attention to and uniformity in the carrying out of details is considered to be of the utmost importance in producing pressure-tight castings.

METALLURGICAL PROBLEMS

Straight Grey Cast Irons

For a great many pressure-tight castings where the design is simple and the stresses are amply catered for in the thickness and design of the castings, straight grey cast irons are suitable and are most generally used for this class of work. Provided the carbon content is not too high and the silicon content is adjusted to suit the mass and section of particular types or groups of castings and the moulding practice is also suitable, there should be no difficulty in producing castings which will regularly and consistently machine perfectly and fulfil the conditions and the pressures specified. Although large quantities of pressure castings are still produced with a phosphorus content of 0.7 to 1.0 per cent., where pressure tightness is the main consideration, compositions where phosphorus is limited to approximately 0.2 to 0.3 per cent. will enormously assist the foundrymen in getting the desired result, namely, consistent soundness and freedom from porosity in the finished article. Such compositions, made in the cupola, without the addition of steel scrap, can be relied on to give a tensile strength of 13 to 15 tons per sq. in. on a 1.2-in. bar, but although with the use of refined irons or medium carbon irons tensile strengths of 16 to 18 tons may be attained, this strength cannot be obtained with consistency.

Steel-Mix Cast Irons

Where pressure-tight castings have to withstand greater stresses, for many years it has been common practice to use steel-mix cast irons, cupola melted, the final composition sought being within the following range:—T.C, 2.8 to 3.2 per cent.; phosphorus and sulphur, low; manganese, 0.7 to 1.0 per cent., with silicon adjusted to suit not only the mass of the individual casting, but also varied in accordance as the total carbon content varies from the lower to the higher figure given.

This type of composition, although only giving tensile strengths in the region of 15 to 18 tons per sq. in., according to the analysis and percentage of steel in the charge, has proved extremely useful in providing a simple means of improving the quality and pressure soundness of a wide range of types of castings.

Given careful cupola control and sufficiently high casting temperatures, a close-grained, moderately uniform material will result, even in castings of considerable sectional thickness and diversity.

Emmel Process

In this connection it may be of interest to glance back for a moment at the main features of the Emmel process for manufacturing high steel-mix cast irons. After all, the technique of this process forms the basis of more advanced types of synthetic and inoculated cast irons whether they are alloyed with other elements, or the straightforward types.

The Emmel process consisted essentially of melting 60 to 80 per cent. steel scrap in the cupola, under carefully controlled conditions, with the addition of high-silicon pig-iron, ferro-silicon and ferro-manganese in the charge, to give total carbon ranging from 2.6 to 3.0; silicon, 2 to 3 per cent.; the phosphorus being kept low. By this means remarkably high strengths were regularly obtained—an average normal figure being 20 to 22 tons per sq. in., and provided the melting operations were carried out with great precision higher strengths could be obtained. This process was never popular, chiefly because cupola practice in this country rather lagged behind and it was difficult for foundries to get the desired results with any great certainty.

Before leaving the ordinary steel-mix types of grey cast iron as used for pressure-tight castings, it is interesting to note that, in making such irons, there are two distinct methods adopted. Until fairly recently percentages of steel scrap in the region of 30 to 60 per cent. were common. Recently there has been a tendency to use a base iron, containing little free graphite, that is to say, the amount of graphitic material being charged into the cupola is reduced to a minimum. White or mottled irons, rich in combined carbon, are mixed with grey-iron scrap obtained from the same type of mixing and lower percentages of steel scrap (perhaps 15 to 30 per cent.), the desired silicon content being obtained by ferro-silicon additions to the cupola charge.

Synthetic and Inoculated Cast Irons

Although this Paper is intended to deal only with problems closely connected with the production of pressure-tight castings, and is not intended to cover the field of special irons which are now produced for their high strength, wear and heat resistance qualities, yet these irons are to-day being increasingly used for pressure-tight castings.

Just as castings become more complicated and intricate, so also they are subjected to higher stresses, higher temperatures and to conditions where resistance to wear is of paramount importance. Synthetic and so-called inoculated irons, mostly produced under proprietary processes, are finding great demand. Some of these have properties which render them easily and readily castable, others require more care and forethought in the provision of suitable moulding practice to meet the limited freezing ranges, high pouring temperatures and similar conditions. Some contain only the usual elements to be met with in ordinary grey cast irons, others contain alloying elements, some are cupola melted, while others are normally produced in various types of rotary furnaces.

This naturally leads one to consider alloy cast irons and the benefits to be derived from alloy additions either singly or using two or more elements in suitable proportions. As far as pressure-tightness in castings is concerned, the alloys most commonly introduced are, in alphabetical order:—(*a*) Chromium; (*b*) copper; (*c*) molybdenum; and (*d*) nickel. These elements will be dealt with, very briefly, only as far as they help to promote pressure-tightness and soundness in castings, and not from the point of view of additions to obtain high strength materials.

Chromium

Chromium is normally used to give increased hardness through its tendency to promote the formation of carbides. Generally speaking, it is used to give increased strength, hardness and wearing quality. However, in the case of pressure-tight castings, it is of little benefit by itself, and even when introduced along with nickel in suitably balanced compositions it is seldom used for the purpose of attaining improved soundness.

For the production of heat-resisting irons, of course, chromium additions in the presence of the correct percentages of nickel are to be highly commended.

Copper

Copper promotes graphite formation in grey cast iron. It is claimed that it refines the graphite, reduces chill, and in this way gives a denser matrix and may be of some benefit in inducing pressure-tightness. In percentages of from 0.5 to 2.0 per cent. it appears to have only a very mild graphitising effect, and the whole question of the limit of solubility of copper in cast irons, in the author's view, requires further investigation.

Copper-chromium and copper-molybdenum cast irons are used in some instances, but these combinations are mainly employed to produce higher strength material, and not, in any way, to give an easy way of arriving at pressure soundness in complicated castings.

Molybdenum

This element is used in cast iron more for the purpose of giving increased strength than to promote uniformity of structure. Where severe duties are encountered in castings to withstand high pressures, molybdenum in conjunction with nickel or chromium, or both, will give considerable improvement in the strength and soundness, and although an expensive element it has its field of usefulness, particularly where high-test irons are required.

Nickel

For a number of years straight nickel additions have been made to moderately low-silicon cast irons with the sole object of getting uniformity of structure and pressure soundness in castings of varying sections.

Nickel additions of the order of 1 to 2 per cent. in cast irons in which the silicon is controlled at a predetermined low figure, by promoting regularity and denseness in all sections, provide a simple and foolproof method of obtaining good results where pressure-tightness is the main objective.

Nickel is a graphitising element, but it also produces a denser, stronger matrix and its chief value lies in the fact that it successfully eliminates "section-sensitivity" in complicated castings of widely varying sections. It is true that silicon adjustments alone can be made to give denser structure in high-pressure castings, but when the silicon content has been lowered sufficiently to give density in the heavy sections, grave trouble is usually experienced with hard edges and risk of hardness in the thinner sections. Properly-controlled silicon plus nickel contents form a valuable assurance against this risk.

Where very heavily stressed castings have to be made or where it is desired to reduce scantlings, nickel cast iron of the type which is marketed under the trade name of "Ni-Tensyl" offers great scope to those foundries which require high-test irons combined with reliable pressure-tight qualities. This is a synthetic inoculated iron, the properties of which are well known.

(*Concluded on page* 238.)

A Novel Development in Melting Practice

THE WALBRO CUPOLA ATTACHMENT

By VINCENT C. FAULKNER

A visit to the Townfield Foundry of G. & W. Walmsley, Limited, of Peabody Street, Darwen, Lancs, left the writer in a somewhat chaotic frame of mind, because, whilst the real object of the visit was to examine and describe the construction of a new type of cupola, he now finds it difficult entirely to dissociate the actual furnace from a system of foundry operation. It does seem desirable, however, first of all to attempt to study the cupola as a melting machine, and then to pass on to its essential suitability for continuous production.

Fundamental Principles

The construction of the Walbro cupola is radically different from every other type, inasmuch as the normal form of tapping spout is replaced by a centrally disposed hole, which is never closed. The actual hole in the earlier stages of the development of the cupola was formed by the insertion of a nozzle such as is used in connection with a bottom-pouring steel ladle. Experience has shown, however, that by

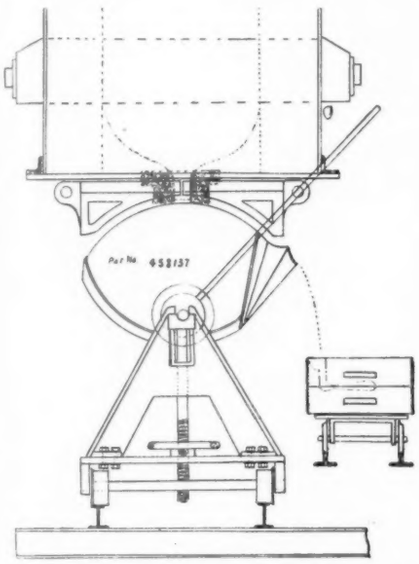


FIG. 1.—DIAGRAMMATIC SKETCH OF THE WALBRO CUPOLA AND CASTING SYSTEM.

the insertion of an annular type of casting suitably covered with a high-grade plastic refractory, an aperture can be formed which will last for several days. This feature and the formation of the bed is clearly shown in Fig. 1. So far, then, the system is simplicity itself, and it now remains to discuss the major influences of such a change. The first outstanding change is the elimination of the well, which effectually prevents the cupola from being a reservoir of liquid metal. This may be a disadvantage in some cases, but, on the other hand, it discloses many potentialities of real value. By contact with the incandescent coke, iron is considered by general consensus of opinion (1) to absorb carbon, and (2) to absorb sulphur. In the present case the slag does not remain in contact with the incandescent coke and molten metal within the furnace. Only in the receiver are they in contact. Dealing with these three factors *seriatim*, the following can be deduced, and most of these deductions have been confirmed in practice, either at Darwen or in other installations where the Walbro attachment is used.

Carbon Absorption

The construction of this new form of cupola maintains the essential principles of cupola operation, and no reason is obvious why such blowing systems as the Poumay or the balanced-blast should not be incorporated, if thought desirable, as it allows the molten iron and slag to be in contact with the coke for a minimum length of time. Experience has shown that there is virtually no carbon pick-up at all. This opens up the next phase, and that is, if, as is generally accepted, carbon pick-up involves an endothermic reaction, then consequently the metal should be hotter. Moreover, as carbon pick-up is a function of time, and time in this case is the irreducible minimum, it presents the feature of yielding iron of a uniform composition, providing the composition of the solid charge is uniform. The temperature of the metal being tapped at Darwen was extremely hot, and temperatures measured by the Ether immersion pyrometer are stated to have yielded figures ranging between 1,350 and 1,400 deg. C.

Sulphur Pick-up

It should be borne in mind that the Darwen foundry is quite a modest organisation, with little facility for extensive scientific experiment, and the figure of 0.011 per cent. sulphur pick-up has been given to them by an outside laboratory as a reliable figure upon which to base calculations. It appears reasonably obvious that this system of cupola operation presents much interest as an experimental unit for the study of cupola reactions, in that it eliminates the variations due to the time-bed-coke factor, and as such is worthy of consideration by university, research and technical school authorities. Even with a tap hole constantly open, there is introduced a time element to be associated with flowing across the bed.

Slag Separation

This feature of the non-mixing of incandescent coke, liquid iron and slag may show up features of special interest. In the case under review, for instance, it has been found possible to eliminate all limestone additions, whilst in connection with another installation it was stated that they were of a very minor order. This has the effect of reducing very materially the wastage of refractories and the incidental cost of extensive patching. Mr. Walmsley assured the writer that the combined cost of patching the cupola and receiver was less than is usual for the cupola alone. Even if a high lime slag be carried, it would have but little effect on the lining because of the low time factor.

An analysis of a sample of the slag taken at the time of the visit has been received. It seems germane to remark, however, that the metal content of slag as reported from the laboratory can very easily be misinterpreted, as no indication is given as to quantity. It is quite easy to increase the quantity of silica and lime so as to show a low iron figure due to dilution. In this case, however, no lime was being used, and the quantity of slag produced was of a low order. The iron content reported is but 2.45 per cent. and the manganese 1.43 per cent. The ratio of manganese to iron appears to us to be a little higher than normal.

Continuous Operation

The fact that there is no "botting up" of the tap hole has immediate repercussions. Primarily, it does not lend itself to shanking without the interposing of a receiver of some kind, and it commends itself as being specially suited for the provision of small quantities of metal for continuous production. Thus, as a natural rider to this form of cupola came the designing of a suitable receiver. The design is shown in Fig. 2, from which it will be seen that the teapot spout has been incorporated, thus precluding the presence of slag in the metal as cast. Further provision has been made for taking care of the varying depth of boxes, within reason, by adjusting the height of the receiver through its mounting in a slide and taking the weight on the end of a hand-rotated screw. As the cupola is of the drop-bottom variety, the receiver is mounted on wheels running on rails for its easy removal. The cupola at Darwen is of 1 ft. 11 in. inside dia., taking 5-cwt. charges with ½-cwt. coke splits. There are four 5-in. by 3½-in. tuyeres, and the yield is 2 tons per hr. Elasticity in blowing is given by the incorporation of two different size blowers, one carrying a variable-speed control. The receiver is heated up by the playing of the hot gases upon it during the 7-min. interval between blast on and the appearance of the metal.

Weighting the Moulds

As the moulds arrive in front of the cupola on the track, which takes the form of a 9-in. gauge railway, raised a few feet from the ground, they are automatically weighted. This is effected by having a lever carrying the weight, a cast-iron

FIG. 2.—THE CUPOLA BOTTOM AND TILTING RECEIVER.

ingot of about 100 lbs., suspended from a chain. Attached to the lever is a rigid bar terminating in the weight. At the far end of the lever is a round bar located just in front of the cupola, and this end of the lever terminates in a hook, the opening of which is earthwards. When the lever rests between the chain and the bar on the cupola, then the weight is just above the box. When the hook is released by downward pressure and a forward movement of the lever, the weight rests on the box, and, finally, when the top of the hook is placed beneath the bar on the cupola and downward force is applied to the lever, extra pressure is communicated to the mould, because the bar is now the fulcrum of the lever. This system is shown diagrammatically in Fig. 3.

Mould Handling

The mould, having been cast up, is pushed along the track, where very shortly use is made of gravity to convey it to the knock-out. At this position there is, within the area enclosed by the mould track, a fixed sieve of 1 in. mesh and the whole of the sand preparing plant. The

boxes are knocked out by hand, the castings transferred to a heap outside the conveyor, and the box parts replaced on the track and pushed along to where it begins to rise. Here a short length of chain conveyor carrying prongs is fixed centrally between the rails in such a position that the prongs engage with the wheeled trollies carrying the boxes and transfer them to the higher level of the shop, where they are pushed along to the moulding machines. There are four moulding machines, two engaged normally on bottom halves and two on copes. The former have been designed and built in the works. The ramming is done by screw pressure, much after the manner of the copy-press. For stripping, the moulds are slid away from the press, automatically turned over and stripped. Top halves are made in Foundry Equipment Company's standard machines. For servicing the plant for the type of manufacture being undertaken at the time of the writer's visit, only nine Sterling steel moulding boxes were being used. Yet three hundred moulds per day were being made, which

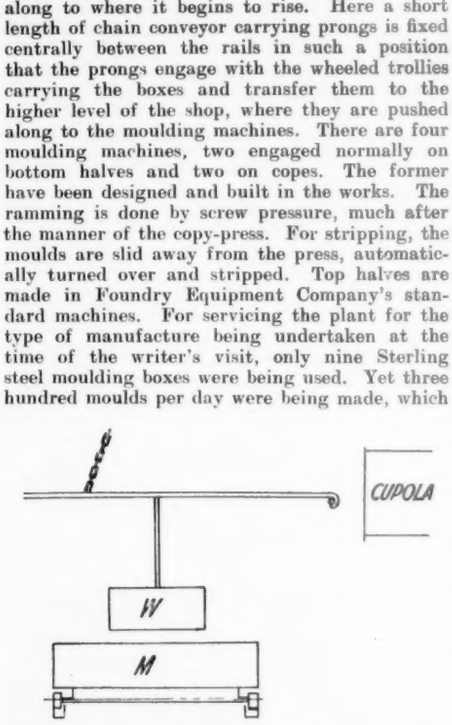


Fig. 3.—Lever Arrangement for Weighting Moulds.

involves their re-use 33 times a day. With the Walbro system it is possible to cast as many as six moulds a minute, and for the operation of the plant there are only ten men.

Sand Preparation

There is but five tons of system sand, and that passing through the sieve, previously mentioned as being the knock-out, falls into a hopper, where a bucket elevator, carrying buckets on a leather belt, feeds a 3-ft. diameter sand mill, using light-weight rollers. It empties centrally into a hopper, whence the sand is taken up a height and allowed to fall through the air to the boot of a second elevator. This latter centrally feeds a cluster of four storage hoppers. These terminate in service hoppers of inverse taperage having metal clam-shell closures. In three out of the four cases, the hoppers are immediately above the moulding box when in position over the pattern, but in the fourth, an inherent constructional difficulty is overcome by directing the stream of sand into position by means of a piece of hinged steel sheet. It may be a disadvantage from a "time-study" aspect, but it certainly tends to spread the sand over the pattern quite evenly and reduces spillage. The problem of cooling the system sand has been solved by the introduction of the two bucket elevators. For the operation of this miniature mechanised foundry, only 8½ h.p. is available.

The weak point of this lay-out appears to be the pushing of the moulds and boxes along the track. This, the writer imagines, could be overcome by more use of a chain carrying prongs beneath the track. When the moulds or boxes require to be stationary, as, for example, alongside the cupola for casting up, then the chain could be made to dip, so as to disengage the boxes.

In thanking Mr. George and Mr. William Walmsley for their kindly reception and the help they have accorded the writer in the preparation of this article, it seems desirable to point out

(*Concluded in next column.*)

Moulding a Motor Spider

The moulding of an electric motor spider was described in a short Paper by Mr. F. Royle at a recent meeting of the Junior Section of the Lancashire Branch of the Institute of British Foundrymen in Manchester.

This particular spider, said the speaker, required two moulding boxes about 2 ft. 6 in. deep, the bottom part carrying bars, up to 6 in. wide, and the other a middle part. To commence work, parting sand was spread on the floor, and the bottom box placed on it with the bars down, floor sand being rammed in the bars, and the cross being placed in and set. The spindle was put in position and more floor sand was rammed around. The pattern was next measured for the spider shaft, about 4 ft. One inch of the pattern protruded over the top box. The box was then measured for 1 ft. 5 in. (2 ft. 6 in. would be in the middle, making 3 ft. 11 in.), and a core-sand bed prepared 6 in. larger in diameter than the pattern. The pattern was hollow, and it was possible to slide it down the spindle. Core sand was rammed around the print and about 1 in. up the pattern.

The next step was to put in the ingate and down runner. The ingate had to be placed so that it met the down runner in one corner of the box, and it had to be made as long as practicable. Ramming the job up was then continued, and two rows of irons put in. Well-fitting pins were needed in making the first joint. The middle part was rammed up in a similar manner, remembering the irons and making sure of some good strong ones in the front of the down gate.

Having rammed to the top of the box, there still remained the 1 in. of pattern above, allowing for the making of a level bed for the spider cores when assembled together. Core sand was spread on top of the box and rammed tight, making this top joint level with the top of the pattern. The pattern was then withdrawn and the mould split. When finishing the bottom, the print was eased slightly, and there was sprigging around the runner and the bottom of the mould. A good coat of blacking was applied, and, when finished, the parts were found to fit together correctly. The mould was given a good stoving.

Mould Assembly

To assemble the mould, it was cleaned out and the runner cut. The box was put in a pit, bringing the joint level with the floor. The first spider core was then put on to the joint and set with the template and the gauges provided. A similar procedure was followed with the second core, and so on, until all the bottom cores were set. After all the spider cores had been set, then the barrel core was put in and centred. The next step was to cover the centre of the cores and the top of the barrel core with a loam plate provided with two riser holes, and to cover the spider poles with cores having riser holes. Pegs were placed in the holes and the runner, a box being put around the cores, as well as ramming with floor sand. For venting, cinder channels were used, which passed through holes in the box, or up the corners and through the top. The barrel core had to be fastened down under the bars of the box or wedged to the weights, the job being then bushed up and the two centre risers fed. The risers of the poles were adjusted, and the peg rammed up in a riser bush.

(*Concluded from previous column.*)

that much commendable enterprise and ingenuity have been displayed by these two foundrymen, and such initiative is well worth emulation by others directing the destinies of concerns of quite modest dimensions. The commercial handling of this plant has been entrusted to Robson Refractories, Limited, of Coniscliffe Road, Darlington.

The speaker pointed out that scrap castings might be caused through soft ramming of the shaft, thus creating swells and dirty castings; and on smaller spiders, where no shaft was necessary, the metal might scab on the green-sand bed at the bottom of the job.

The remainder of the evening was devoted to a try-out of lantern slides prepared by Mr. E. Longden to illustrate a lecture he was to deliver at Glasgow. The slides included illustrations of the making of a 32-ton headstock, a 21-ton cast-iron spindle, a 50-ton hammer block, and some interesting figures of expansion and contraction in castings. These have appeared in our columns.

Making Pulley Castings

Mr. F. Andrew said that on one occasion he had a number of pulleys to make, and the conventional way was to run these on the box. There were about 70 pulleys, with a 30 in. diameter and 6 in. face, and having the usual curved arms (supposedly intended to prevent fracture). He thought he would depart from convention and run them on the rim at the bottom. Whereas previously they had to feed the boss and remove the core and generally bare the boss, they were able to dispense with both feeding and baring, and it was not easily possible to break the arms. The way in which these pulleys were tested was to hit the rim with a hand hammer opposite the end of the arm, and if there was any strain existing in any of the arms, this would release it and leave a broken arm. By running at the bottom of the rim it was possible to get them quite sound and without any strain existing in the arms. Mr. Andrew asked if Mr. Longden would explain how the compression of the rim would be affected by the cooling of the boss.

Mr. Longden replied that in the case of the pulley, the arms, in contracting after the rim pulled the rim inwards. By running it on the rim, they were altering the cooling gradient, and were actually transferring heat to the rim and slowing up the rate of the cooling until the pulley had begun to contract in the heavy centre.

Replying to Mr. Bateson, who asked if Mr. Longden did not think that draughtsmen should consider contraction, he said he had yet to meet or learn of a draughtsman who would not respond to an appeal for improvement.

Mr. Bateson mentioned a case where trouble had been experienced with blank wheels which had been sent away for teeth to be cut, and which had invariably been returned faulty, with contraction cavities at the root of the teeth. The trouble had been remedied by placing a small core at the end of the arm where it met the rim. Had that anything to do with contraction of the rim?

Mr. Longden said that interposing a core between the arm and the rim was not really successful. It might have been sufficient in that particular instance to reduce the amount of cavity so that when the tooth was cut, it did not penetrate it. The idea of fixing a small, slender core between the end of the arm and the rim was a failure, because the small body of sand became rapidly overheated. He never used a core in such position as a remedy for liquid shrinkage. There were much more effective methods of eliminating shrinkage, and all that was necessary was to chill the outside of the rim.

The Chairman (Mr. A. Hopwood) thought Mr. Bateson was referring to different kinds of contraction—liquid shrinkage, solidification shrinkage, and the ordinary contraction in the solid state which was termed "patternmakers' contraction." The contraction referred to that evening had been the patternmakers' contraction—the one which took place after the casting had definitely set.

Mr. Longden termed the diminution in volume of the fluid to solidification "shrinkage," and the solid diminution in volume to room temperature "contraction."

Bronze-Welding of Cast-Iron Pipe*

By Dr. J. T. MACKENZIE (Metallurgist, American Cast Iron Pipe Company)

Realising the importance to the trade of having a dependable and serviceable method of welding plain and cast-iron pipes, the author's company has made extensive experiments and a careful study of the different types of welds, such as the bronze weld, and the cast-iron fusion weld which was developed at Acipco. Each type has been carefully tested and the results compared with the full cross-section strength of the pipe. Two methods of bronze welding have been studied and found satisfactory; (1) the collar-type weld and (2) the shear vee type.

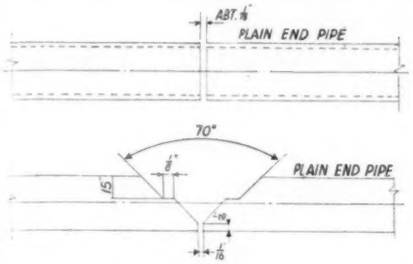


FIG. 1 (TOP).—ARRANGEMENT OF PIPE FOR COLLAR TYPE OF WELD.

FIG. 2 (BOTTOM).—ARRANGEMENT FOR SHEAR VEE WELD.

General Instructions to be Followed in Both Cases

Preparation of Pipe.—For the collar-type weld use plain end pipe arranged as shown in Fig. 1. For the shear vee type, bevel the ends and machine a shear shoulder as shown in Fig. 2. The outside surface of pipes should be thoroughly cleaned in the weld area.

Materials.—Only the highest grade bronze welding rod and commercial fluxes are recommended.

Welding Procedure.—(*a*) Place the pipes on suitable skids or rollers in order to maintain proper alignment during the welding operation. (*b*) Separate abutting ends by about $\frac{1}{16}$ in. (*c*) Before applying the bronze, heat the pipe in the weld area to a cherry red. (*d*) The adjustment of the blowpipe flame varies with the type of weld; in the collar type an excess of oxygen speeds up welding without detriment to the weld, but in the shear vee type, the flame should be neutral to prevent overheating the top of the vee and shear shoulder before the bottom of the vee is heated sufficiently to tin properly; and also the neutral flame has less tendency to burn the bronze. (*e*) Warm the bronze rod and dip in flux, then rub lightly on the heated pipe under the flame. By moving the rod in a slight arc under the flame, the first ripple or lap is formed, then the flame is moved ahead, preheating the pipe for succeeding ripples until the entire circumference of the pipe is welded. (*f*) Keep the pipes evenly supported until the bronze has cooled below its plastic state.

FIG. 3.—COMPLETED BRONZE WELD.

Comparison of the Two Types

The collar type takes less bronze and is much faster to construct than the shear vee type. The shear vee type, due to its construction, is stronger and is to be desired, if the weld is subject to unusual shocks or stresses. The collar type is the more economical and for ordinary conditions should be satisfactory. A comparison of the strength properties of the different welds is given later in this Paper. A picture of a completed bronze weld is shown in Fig. 3.

Procedure for Cast-Iron Fusion Welding

Preparation of Pipe.—First bevel the abutting ends of pipe to 45 deg., giving a 90 deg. vee shape when the pipes are brought together; then the outside surface of the pipe should be thoroughly cleaned for at least $\frac{3}{4}$ in. adjacent to bevel.

Materials.—Only the highest grades of cast-iron welding rod and commercial fluxes are recommended.

Alignment—Allowance for Expansion and Contraction.—Allowances must be made for the warping effect of the expansion and contraction of the metal during welding. This allowance varies with the metal thickness as well as the diameter of pipe. It is also affected by the lengths of pipe welded, the longer lengths tending to counteract this warping or upturning effect. No definite values have been established as yet for these various factors, the allowance made depending upon the judgment and experience of the welder. A gap of $\frac{1}{16}$ in. is left between the abutting ends of pipe where welding is to start, as shown in Fig. 4. Around the circumference of the pipe for 180 deg. the gap is $\frac{1}{16}$ in. plus the allowance for warping discussed above.

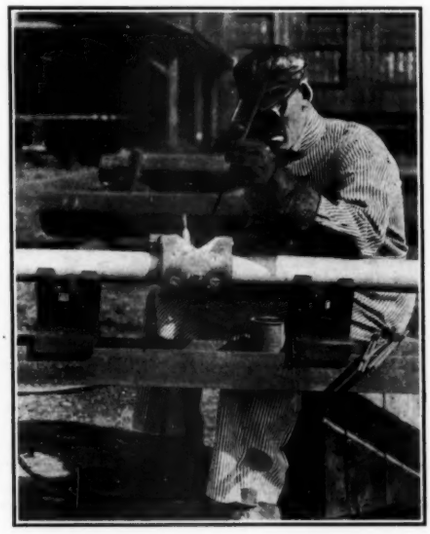


FIG. 6.—MAKING A CAST-IRON FUSION WELD USING HEAT-RETAINING COLLAR.

Welding Procedure.—Before aligning the pipe, a dry-sand core of practically the same diameter as the inside of the pipe is inserted at the abutting ends. This core prevents the collapse of the pipe wall during welding and retains heat to prevent rapid or uneven cooling of the weld. After the pipe is aligned a refractory-lined hinged collar is placed around the pipe over the joint and the welding is done through an aperture of the collar (Fig. 5). This collar is essential to prevent uneven cooling and retains the heat. The blowpipe should be adjusted to a neutral flame using the lowest pressure of oxygen, regardless of the size welding tips used. Fig. 6 shows a weld under construction.

The pipe should be brought to a fusion temperature, the rod warmed and dipped in a good grade of commercial cast-iron flux, and then the rod and flux applied to the molten metal. The molten puddle should be three times the metal thickness in width and extending the full thickness of the pipe wall in depth. During fusion, the puddle should be constantly agitated with the welding rod down to the inside core, in order that slag and impurities may float to the outside. Continue around the entire circumference of the pipe and then rework at least two inches beyond the start of weld to eliminate any blow holes in the first metal laid down.

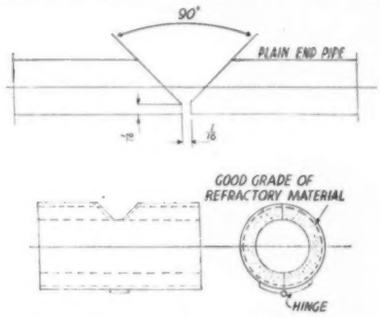


FIG. 4 (TOP).—PIPE BEVELLED FOR CAST-IRON FUSION WELD.

FIG. 5 (BOTTOM).—CAST-IRON FUSION-WELDING COLLAR.

As soon as the welding is completed, the opening in the welding collar is covered with asbestos and the collar is left over the joint for at least one half hour to remove possible welding strains. A completed cast-iron fusion weld is shown in Fig. 7.

It has been found that, when using the heat-retaining collar, the welding tips should be about two sizes smaller than those used without the collar, to prevent oxidising the iron.

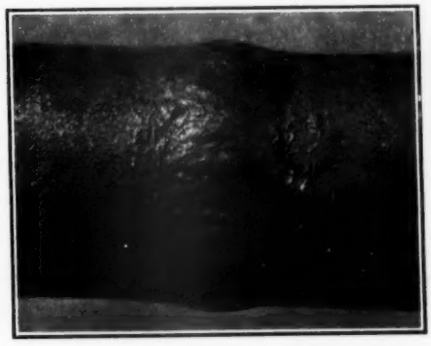


FIG. 7.—COMPLETED CAST-IRON FUSION WELD.

Tests on Welded Pipe

Pipes which were joined together with the various types of welds have been subjected to the accepted standard tests for cast-iron pipe:—(*a*) Internal bursting pressure; (*b*) beam loading; and (*c*) impact, and the results compared with the full cross-section strength of standard pipes without welds.

* Paper read at the 38th Annual Convention of the International Acetylene Association at Birmingham, Alabama.

Bursting Tests

These tests were made on pipe 16 ft. long. The tests on welded samples were made with the weld in the centre. Standard bell and spigot plugs and caps were caulked in the ends as in standard field practice. Each sample was then placed in a structural steel frame to restrain the caulked fittings. The internal pressure was then slowly raised till failure. Failure pressures were read on calibrated hydraulic gauges.

Beam Test

Beam tests were made on the full-length pipe in each test. In the case of welded pipe, the weld was placed midway between the supports.

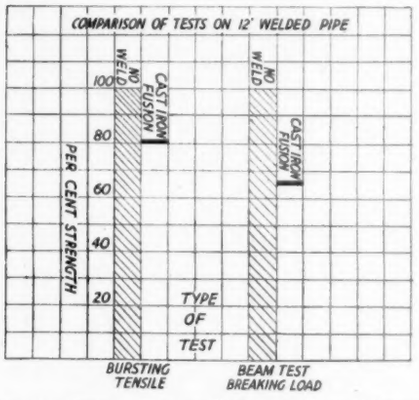


FIG. 8.—COMPARISON OF TESTS ON 12-IN. WELDED PIPE.

The supports were 15 ft. apart and the load was applied at two points, each 5 ft. from the support. The tests were made on a 90-ton testing machine.

Impact Test

Impact tests were made on full-length pipe bedded in moist sand with 50 lb. per sq. in. internal water-pressure maintained while subjected to repeated blows of a 50-lb. falling hammer. The height of drop started at 3 in. and was raised in increments of 3 in. for succeeding blows until the failure of pipe occurred, the hammer being dropped directly on to the weld.

The bronze weld joint does not lend itself to the standard method of impact testing as the bronze is soft and ductile and cushions the

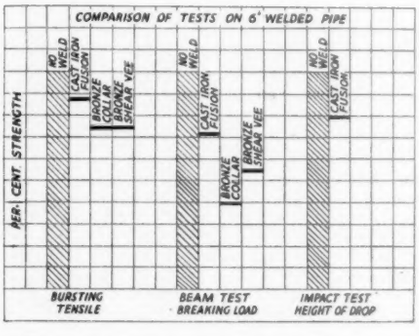


FIG. 9.—COMPARISON OF TESTS ON 6-IN. WELDED PIPE.

blow of the hammer. From all indications the bronze weld joint has no weakening effect on the impact resistance of the pipe itself, and the weakening effect of the cast-iron fusion joint is slight as evidenced by the height of drop of the hammer, as shown in the diagrams, Figs. 8 and 9.

Corrosion of Welds

It is practically impossible in any welding operation to produce a weld metal which has exactly the same structure as that of the metal being welded. This means, of course, that if the welded structure is exposed to an electrolyte, such as very muddy soil, brackish water, or sea water, galvanic currents will be set up which will cause attack of that part of the metal structure which is anodic.

Galvanic action of this type becomes serious only when the positive or anode part of the structure is small in area as compared to the cathodic part of the structure. For example, if a bronze or brass coupling be used to connect two iron pipes, the coupling is cathodic, the corrosion takes place on the pipes, and is spread out over a relatively large area so that the attack is usually not severe at any one point. However, if brass or copper piping is joined by a coupling of ferrous metal the galvanic attack is concentrated on the anodic coupling, and in such cases the coupling is often completely destroyed in a short time. Another point worth mentioning in this connection is the fact that where the cathode is small in area compared to the anode, the reaction is cathode controlled. That is, the progress of the reaction is governed by the amount of oxygen available to remove the hydrogen formed and to depolarise the cathode. For this reason, where the reaction is cathode controlled the total amount of corrosion is often actually less, because oxygen cannot be supplied fast enough to allow the reaction to proceed normally.

The polarity of welds may be determined most easily by what is known as the Agar test. A machined section of the pipe wall through the weld is placed in a clear Agar jell which contains dissolved sodium chloride, potassium ferricyanide, and phenolpthalein. The same solution serving as an electrolyte, any galvanic action

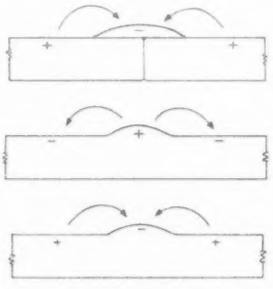


FIG. 10 (TOP).—BRONZE WELD.
FIG. 11 (CENTRE).—PLAIN CAST-IRON FUSION WELD.
FIG. 12 (BOTTOM).—FUSION WELD: ALLOY CAST IRON IN WELD.

starts immediately. Anode points are revealed by the fact that iron going into solution reacts with the potassium ferricyanide to produce a deep blue colour in the jell adjacent to any anode point. Cathode points are shown by a red colour in the jell, which is caused by the sodium hydroxide forming at the negative poles and changing the colour of the phenolpthalein.

Fig. 10 shows a section of a bronze weld of monocast pipe in which the polarity was determined by this method. As may be seen, the weld metal is cathodic to the pipe itself so that the corrosion would not take place on the weld, but would be spread out over the entire pipe. For this reason, bronze-welded cast-iron pipe presents no serious corrosion problem.

Fig. 11 shows a section of a cast-iron fusion weld. In this case the weld metal is distinctly anodic to the rest of the pipe, and under favourable conditions the galvanic corrosion might easily cause failure through concentration of the attack upon the weld.

Fig. 12 shows one way in which this problem is solved. In this case the fusion weld was made with an alloy cast iron for the weld metal, when the weld becomes cathodic to the pipe wall and therefore no corrosion problems would be expected.

Labour and Materials Required for Welding

The figures below were assembled to give a comparison of the cost for making the two types of welds discussed in this Paper. In each case the figures were taken from approximately 100 welds made during a normal workday in the line of production. These welds were made on a special line of pipe manufactured at Acipco and therefore are of no value except in a comparative manner.

	Bronze-collar type.	Cast-iron fusion.
Time required for making weld in minutes (welder and helper) ..	7.38	15.79
Cub. ft. of acetylene	2.08	3.30
Cub. ft. of oxygen	2.44	4.34
Welding rods in ounces	2.25	2.28
Flux in ounces	0.12	0.11

NOTE.—No extra cost is shown for preparation of pipe for welding.

The Iron and Steel Institute

NEW OFFICES ACQUIRED

In a preliminary notice the Council of the Iron and Steel Institute announce that they have arranged to take a lease of 4, Grosvenor Gardens, London, S.W.1, and that the offices of the Institute will be moved to that address in a few months' time. Arrangements have been made to sublet a part of the building to the Institute of Metals. The Councils of the two Institutes have also agreed to the amalgamation of the libraries and the formation of a joint library on metallurgy, to include the specialised libraries of the two Institutes. The new library for the use of members of both Institutes and of the industries with which they are connected will be under the control of the Council of the Iron and Steel Institute, with a Joint Advisory Committee consisting of representatives of both Institutes; Mr. R. Elsdon will be the Librarian in charge and he will also continue to direct the information service supplied by the Iron and Steel Institute to members and the industry. The date of removal to the new offices will be announced in due course.

Production of "Pressure-Tight" Castings in Grey Iron and Its Alloys

(*Concluded from page* 234.)

Melting Practice

The cupola is still the commonest form of melting furnace used in the production of pressure-tight castings in this country. It is well known that there is such a great diversity in the construction and performance of different cupolas that it is almost an impossibility to make any serious comments on cupola control.

Sufficient it is to say that every cupola should be so constructed and so controlled that it will be capable of giving consistently high temperatures over long periods of running. Where it is impossible to superheat the metal to the desired degree by auxiliary means, and that is the exception rather than the rule, then the cupola should be adjusted or reconstructed to give temperatures sufficiently high to ensure pressure-tightness in the type of cast iron being used. Where rotary furnaces are in use, the question of adequate temperatures does not arise, and carbon control can be much more easily effected.

In conclusion, it is suggested that the few points raised in general terms on this subject of pressure-tight castings—a subject of immense importance to the foundry trade—may tend to shape one's thoughts into the way of treating every type of casting as an individual problem.

Some Aspects of the Casting of Commercial Ingots*

By W. A. C. NEWMAN, B.Sc., A.R.S.M., A.R.C.S., F.I.C.

The casting of ingots, in one form or another, is an integral part of the foundryman's profession. Ingots may almost be considered the raw material of a large section of metal manufactures. Much research work has been carried out in recent years on ingot production, both ferrous and non-ferrous, and the problems which have arisen therein are common to those handling liquid metal.

Three Classes of Ingots

Commercial ingots may be conveniently divided into three classes:—(1) Ingots of pure metals obtained as the final products of the extraction plants; (2) ingots of alloys, manufactured according to specification, for sale, or for the primary object of obtaining metal of uniform composition to be remelted for special purposes, and (3) ingots—of pure metals or alloys—which are intended for mechanical working such as rolling, forging, drawing, etc.

The conditions which must be met in the production of these three classes are not all similar nor of equal importance. In the first group guaranteed purity is essential; the ingots must be in a form which is easily handled, and it is preferable if they are acceptable in appearance. Yet as they are not to be employed in any structural part or similar product without further treatment and are rarely used alone, they are not subject to mechanical tests, nor are foundrymen particularly interested in the internal soundness or structure except as these indicate impurities. Similar considerations apply in the case of the second group, except that here uniformity of make-up and of ultimate composition is superimposed on purity. In the third group, however, the demands are more stringent, for on the characteristics—physical, chemical and mechanical—of the original ingot depend, in a very great measure, the success and efficiency of the succeeding manufacturing operations. It is, therefore, to this class that most attention has been directed, and some knowledge has been gained—by no means yet completely—of the influence of such factors as method of casting, temperature, mould material and shape and mould dressing on crystal structure, segregation, soundness and surface condition, and of the further influence of these latter on the behaviour of the material during mechanical working.

The casting of pure metal ingots occurs after the final refining operation and usually consists either in tapping direct from the furnace into chill moulds or through an intermediate ladle or kettle where final skimming may be done, or by simply ladling out by hand from some such kettle in small quantities at a time. It is important that the refined metal shall not absorb excessive impurities in transit to the mould and that precautions should be taken, especially in the case of easily oxidised metals, to prevent contamination from the air.

Such methods are adequate for what one may term the minor base metals, tin, zinc, etc., where the production is comparatively small and the temperatures concerned are not high, but in the case of copper, lead, etc., where the amounts involved are considerable, and relatively high temperatures are necessary, modern practice in the largest plants demands mechanical aids.

The Case of Copper

Copper from the reverberatory furnace is cast into moulds—for anodes, wire bars, flat cakes or ingot bars—which in large-production work are carried on some type of continuous conveyor, most commonly a casting wheel. The metal passes from the tapping spout of the reverberatory to a launder which slopes into a pouring ladle. This holds about 1,000 lbs. of copper, and has a lip 6 in. above the casting surface of the mould. A bridge piece keyed into place about 1¼ in. above the bottom of the ladle and 14 in. back from the lip gives a measure of bottom pouring and keeps back scum. The casting wheel is usually situated in a pit below the floor level on which the furnace is built.

The essential features in a good casting wheel are:—(1) Sufficient strength to carry the load when working to capacity; (2) ease of control from a central position; (3) a positive drive; (4) easy and smooth acceleration and freedom from vibration or lurching, and (5) no back lash, so that there is no hesitation or shaking when changing the moulds under the stream.

The average casting wheel is 33 ft. to 36 ft. in diameter. It has a heavy circular bedplate on the upper face of which is a machined track to accommodate radially tapered rollers which carry the main cylindrical casting forming the hub. The moulds are carried at the ends of radial arms fixed to a centre boss and may be horizontal or open, or, as in some recent instances for anode and wire bar castings, vertical (or so-called "closed") and water cooled. On the outer ends of the arms there is provision for the housing of levelling blocks to receive the trunnions on the ends of the moulds. Usually up to 22 or 24 moulds are carried and each mould serves for the casting of three to five ingots at a time. A 15-h.p. motor drives a vertical slow-speed pinion (or pinions) through suitable reduction gear and variable-speed reversible oil gear, and this pinion engages a rack on the inside of the main wheel casting. The maximum speed is one rev. in 3 min. The highest accuracy in construction is required in order to minimise vibration.

As each mould passes, the ladle is tilted, and when the mould is full, the ladle is tilted back again. The wheel is then moved to bring another mould into place. The molten stream is divided by a refractory wedge-piece, when wire bars or ingots are being cast, but is maintained as a wide stream—30 in. or so—when anodes 36 in. wide are being prepared.

The ingots are completely solid when about four or five mould positions past the ladle, and here are cooled by water sprays above and below. Cooling of the bottom of the moulds during actual casting is also practised in order to induce solidification from the bottom.

When the ingot is solid, one end is raised automatically by two cast-iron pins fitting through two countersunk holes in the mould and, assisted by gravity, the block then drops into a bosh or water tank for complete quenching. Alternatively, there is a finger on the rear of each mould, and this finger is provided with a roller bearing sleeve situated obliquely to the upper face of the mould and pointing to the centre of the wheel. When the ingot is solid, this finger engages with guide rails, and the ingot is thereby turned on its own axis until finally it is dumped into the bosh. Subsequently the mould is gradually returned by the guide rails to its normal position. The ingots are finally taken by a conveyor or lifted by a crane on to a truck. The weight of ingots per mould is of the order of 700 to 800 lbs. The casting temperature when using mechanical devices of this character is considerably lower than when casting normally from crucibles or similar smaller containers.

Mould Materials

The moulds into which the metal is cast were originally made of cast iron, but their poor thermal conductivity, combined with the comparatively short life before cracks developed, and the consequent high cost, inspired investigations into other mould materials. Eventually copper moulds were adopted, and in most recent practice these are, in addition, water-cooled.

The discovery of the effectiveness of copper itself in this connection offered a means of internal manufacture which was economical. Refined copper is used as the mould material, as even small amounts of impurity lower its thermal conductivity sufficiently to impair its efficiency.

Life of Moulds

Sand casting of the moulds was first employed, using a wooden pattern. More recently collapsible cast-iron mother moulds have been installed on a separate platform near to the tap hole, so that the stream from the refining furnace may be diverted in part whenever moulds are to be made. The collapsible frame is set on a heavy copper base and is stationary beneath a press on which copper dies are mounted. The exterior surfaces of the latter correspond to the interior surfaces of the copper mould required. When the frame is full of molten copper the latter is cooled slightly and then skimmed, the dies or cores are lowered into it and remain there until the metal is set. They are then raised, the copper mould allowed to cool and afterwards accurately machined all over. For moulds intended for wire bars or flat cakes, water-cooled cores are used; for moulds for ingots and ingot bar moulds, solid copper cores are sufficient. The cores should not remain in the molten metal too long or excessive shrinkage develops and may cause transverse cracks in the pockets. On the other hand, lifting the cores before solidification is complete may result in a run of molten metal. A series of perfect moulds is in this way always available; no mould need be used after it has developed a fault. Usually 50 to 200 tons of finished ingots per mould are obtained, though, on rare occasions, a mould may last for up to 60 heats or 300 to 400 tons of ingots.

Scrapping of moulds is usually due to the development of cracks where the stream of metal first hits them. They also tend to sag in the centre. Discarded moulds are returned to the furnace, thereby reducing charges to the mere cost of making the moulds on the spot.

When a new mould is introduced, or a wheel is starting from cold, a small charge of copper about ½ in. thick—"a warmer"—is run into each mould to warm up the latter and expel moisture. These are then returned to the furnace. The temperature of the moulds is carefully controlled by a surface pyrometer.

Mould Dressings

A common dressing is a wash of very finely ground (93 per cent. passing 200 mesh) silica or bone ash mixed with water, which is sprayed on with a gun and then dried by a blast of hot air. The consistency of the dressing is important. It is usually mixed in a tank and its specific gravity checked by a hydrometer immediately before application. Where the moulds are water-cooled the life is considerably longer. The face plates are cast in special mother moulds on the site.

Quality Control

The testing of the copper—whether it be for wire bars, anodes, or ingots—is performed regularly by taking small dip samples from the stream at short intervals, say every 30 minutes. These are examined for fracture and by visual inspection for oxygen content. Any undue oxygen absorption is quickly detected by the appearance of blackish spots on the surface of the small test-bars. There is a tendency for the oxygen content of the metal

* Paper read before the London Branch of the Institute of British Foundrymen, Dr. A. B. Everest presiding.

in the furnace to increase as casting proceeds. This is countered by renewed poling or by placing a small quantity of charcoal in the intermediate ladle. Billet samples are also obtained during the run and drawn into wire for the determination of conductivity in a standard apparatus. Drill samples at appropriate intervals are used for chemical analysis.

Common Defects

Faults which may appear in the ingots and the causes to which they are normally attributed may be summarised as follows:—

(1)	"Set" too convex.	Poling carried too far or temperature too high.
(2)	"Set" concave.	Poling not carried far enough or too low a temperature.
(3)	Irregular holes containing moisture.	Dressing of mould not dried sufficiently.
(4)	Deep seated holes especially at contact point of metal and mould.	Too high temperatures of metal and mould being employed.
(5)	Severe porosity.	Oily dressing used in too large a quantity.

Recent practice has tended rather to the use of vertical moulds for anodes and wire bars instead of the former flat ones. Less surface is thereby exposed to atmospheric oxidation. It is found, too, that the average oxygen content is lower in a vertically cast bar than in one cast in the horizontal position. Greater density is obtained in vertical cast bars—8.64 to 8.83 against 8.59, but the densities of the wires drawn from the two kinds are approximately the same. Vertical bars have also higher electrical conductivity and elongation, but their tensile strength is somewhat lower. Their general workability, however, is greater. Horizontally-poured bars give a superior rolled product if the upper wrinkled surface is planed away.

Casting Gold

The casting of gold ingots is unique because of the value of the metal and the peculiar position in which such ingots stand in the settlement of international trade. They are usually made as nearly as possible of the same weight, and especial care is taken to ensure a specular surface and a general good appearance. To these ends, the metal, after being melted in small-capacity furnaces, is poured into a carrier pot and then cast into an ingot mould which is resting on the pan of a balance so that pouring may be stopped as soon as the beam begins to move. During pouring, too, the whole of the upper part of the ingot mould is enveloped in the flame of burning acetylene or coal gas in order to maintain a reducing atmosphere and produce the bright, smooth surface required.

Similar methods are also employed for the so-called "10-oz. bars" which are made for circulation in the East. In this case, however, even greater care still is exercised in obtaining a standard weight.

Making Alloy Ingots

Ingots of the second class to which reference has been made are mainly cast (1) for sale or (2) to ensure uniform composition, before being melted in larger bulk preparatory to being poured into large castings.

The melting is usually done in crucible furnaces of any of the well-known types fired by gas, coke or oil, and the ingot moulds, made usually of grey iron, are arranged side by side or on a small turntable. Suitable arrangements are made for temperature control, for deoxidation, for the skimming of the metal and for prevention of oxidation while the metal is passing from crucible to mould and whilst it is solidifying in the mould, preferably using bottom pouring and by pouring through a gas flame.

The melting of large batches is done in small reverberatory furnaces which are tapped into ladles, whence the metal is poured into sand moulds. Attempts have been made to manufacture alloys of the brass and bronze type for casting into small ingots for sale, in such reverberatory furnaces but with indifferent results, especially where the metal content is strictly specified. Mixing and the control of composition are not obtainable to the same high degree as when crucible melting—implying smaller batches and more efficient stirring—is practised. Remelting, however, serves to adjust small differences and to yield a product which is reasonably uniform in bulk.

Ingots for Rolling

The casting of ingots which have to be rolled or otherwise worked involves the production of material of the highest chemical, physical and mechanical character. Such ingots range from the thin strip castings suitable for cold rolling to the large 5-cwt. or 10-cwt. slabs of non-ferrous alloys and the still larger steel ingots weighing up to nearly 200 tons.

So far as non-ferrous ingots are concerned, melting of the alloys is carried out in crucible furnaces of all types and in the well-known electric furnaces such as the Ajax-Wyatt, the Ajax-Northrup and certain rotating barrel types.

Ingot Moulds

The casting of ingots implies casting in chill moulds, regular in shape with no intricacy of design, but through which the heat from the casting is transmitted and afterwards dissipated by radiation. The days of the old stone moulds are far past, and since the 19th century metal moulds have been common, but the nature of the metal which should be used is a question still in the forefront of foundry practice and has, within recent years, been the subject of much investigation. It is now no longer understood that a mould is merely a container into which molten metal is poured and then allowed to cool. It has been realised that the mould has a significant effect on the character and the structure of the ingot formed within it. Too much attention cannot be given to securing good moulds of the best material.

Until comparatively recently the normal type of chill mould used for non-ferrous ingots was made of cast iron, preferably of close-grained hematite iron, having a composition within the following ranges:—Graphitic carbon, 2.5 to 3.6; combined carbon, 0.1 to 0.4; silicon, 1.5 to 4.0; manganese, 0.2 to 1.2; sulphur, 0.06; and phosphorus, 0.23 to 0.5 per cent.

A high phosphorus content is conducive to fluidity and the production of good castings. On the other hand, some aver that the compound Fe_3P is deleterious and conducive to a shortened mould life. These manufacturers thus prefer a low percentage of phosphorus.

In general such iron is cheap, durable and can be cast with a smooth surface. The moulds themselves should be cast face downwards and with sufficient inclination to carry any slag upwards. As nearly as possible the metal in the mould should be equalised so that it should suffer no distortion and the ingot cast in it should have uniform cooling all round. It is usually found that the hard casting skin on such moulds is beneficial, and that where it is machined away, in order to improve the surface somewhat, cracking occurs earlier. Annealing or "blueing"—heating the moulds to a dull red heat—counters this to a certain degree and in any case relieves casting strains.

Iron moulds for cast-iron castings have a somewhat different composition from that employed for ingots in non-ferrous work. An analysis would show total carbon, 3.5 to 3.6; manganese, 0.6 to 0.8; sulphur, 0.05 to 0.06; and phosphorus, 0.4 to 0.6 per cent. In casting the mould itself in dry sand, the interior surface is formed by a nearly cold steel core to give chilling. Chills are also used around the outside. The life of such a mould—as indeed of all moulds—depends, apart from the correct composition and proper casting, on the casting temperatures of the ingots, the time the cast ingot is in the mould, the temperature of the mould during casting and the coating used on the mould surface.

In non-ferrous work parallel sided moulds are almost universally used, whereas in steel practice tapered moulds are employed. The former have a good many disadvantages from the point of view of producing sound ingots, but they form ingots which are more suitable for rolling. In general, more solid metal is obtainable from tapered ingots and in those in which the larger section is uppermost than from those cast the reverse way. There are fewer gas holes, but contraction cavities still persist. Increasing the taper increases the soundness and, at the same time, in the average ingot, the columnar crystals become larger. The surface quality, however, is not materially changed.

Ingot moulds fail principally in two ways by (1) major cracking, due to factors of design or casting or to changes in properties produced by structural changes following heating, and (2) minor cracking or crazing, attributable to oxidising and stress effects, including growth. This type of failure is increased by a high silicon content of the mould material.

The cracks, both transverse and network, which sooner or later appear on the surface of a mould transmit the defect to the ingot, and this is fatal where the latter is to be rolled, because it results in overlaps and an imperfect rolled surface, only removable by planing or scalping. Such a crack in a mould holds a certain amount of dressing and almost invariably results in a "blow," due to the sudden vaporisation of volatile oil. It is found, too, that the cracks most readily occur in a mould whose section is variable, *e.g.*, in strip moulds which have lugs to support them on the cross bars of the mould carriage or frame, cracks invariably occur first opposite the lugs. Various methods have been tried to overcome this cracking—filling them in with an iron cement, filing them down at the proud edges and filling daily with china clay, but none is really effective in prolonging the life.

The expedient has also been tried for strip moulds of introducing mild steel strips, $\frac{1}{8}$ in. thick and cut to the shape of the moulds, in between the latter to give an artificially new surface to replace a cracked back. These plates are held tight when the moulds are screwed up in the carriage. The results so far are promising. Some plates now in use have survived 700 heats and show little sign of deterioration.

It is invariably found that unless cast-iron moulds have intermediate treatment during their lives a very hard skin forms, which results in the ingots being pimply or even short. A treatment which has been recommended is to scrub the surfaces with a stiff wire brush, and follow this with an application of thick tar. The mould is then annealed, when the mould surface recovers most of its original condition. In the casting of brass ingots in cast-iron moulds it has been found advantageous to clean the latter daily by first soaking them in a hot 10 per cent. solution of caustic soda, which softens and partially dissolves the hard skin—containing some 60 per cent. zinc—which forms on the surface, and then scraping them with a sharp tool.

Inherent Disadvantages

Three of the serious disadvantages of cast-iron moulds are: (1) the gas evolution during pouring; (2) the growth of the cast iron, and (3) their low heat conductivity and high thermal stress during casting.

The gassing which has been attributed to the iron is probably primarily due to overheating by contact with the molten metal. Contributory causes are the porosity of the iron and the re-

action between the superficial oxide on the metal and the carbon in the iron—probably the combined carbon rather than the graphitic—which is accentuated by the effects of the mould dressings.

The substitution of mild steel for cast iron diminishes the blowing and cracking effects, but two other serious defects arise, viz., distortion of the mould and the liability of the molten metal to weld on to the steel. This latter trouble has been met somewhat by aluminising the surfaces of steel moulds.

In all usual types of cast iron one has to contend with so-called "growth." This has been attributed to the precipitation, then solution and afterwards reprecipitation of the graphite in the matrix of the mould, and more latterly by Carpenter to the repeated oxidation of iron silicide. The presence of nitrogen and hydrogen increases the amount of growth, while P and S and Mn appear to diminish it. In large ingot moulds as much as $\frac{1}{4}$ in. decrease in internal measurements due to this cause has been observed after 150 heats. Incidentally it has been found that moulds made from cupola iron can with advantage be made initially more accurate, with a reasonable chance of remaining so, than moulds made from straight (or direct) metal. The latter, however, generally have the longer life.

Nickel cast-iron moulds have been used in order to try and reduce some of the ill effects of grey iron, but personal experience is that, apart from being more costly, they are not altogether satisfactory and show defects of their own.

In the case of moulds for steel ingots, which are usually much larger than for non-ferrous work, it has also been shown that for each kind of steel there are special—almost critical—conditions which the mould has to fulfil. Shape, taper, diameter, length, and proportion of wall thickness to ingot body are all important. The material mainly used is low in S and P, with a high total carbon content. Some recent results, however, have revealed the greater durability of ingots containing high percentages of phosphorus. Thus:—0.240 per cent. P, 120-130 heats; 0.170 per cent. P, 130 heats; 0.070 per cent. P, 115-120 heats. The Si is such as to yield a soft grey iron, for a mottled or white structure would probably cause premature cracking. So many factors intervene, however, that it is almost impossible to correlate mould life with composition. Pearce, as the result of an extensive survey, suggests the following ideal specification for a mould for steel ingots:—Total C, high $\not<$ 4.3 per cent.–0.3 × Si per cent.; Si, sufficient to yield a grey all-pearlite iron; Mn, 1.7 × per cent. S + 0.3 per cent. min.; S, < 0.1 per cent.; P, < 0.1 per cent.

Pearce also is of the opinion that a suitable *structure* for an ingot mould for steel would be that of a high-carbon iron to confer resistance to the hot stream of metal, with a very fine graphitic structure to prevent the entry of oxidising gases and thus delay growth. This particular combination is normally not easy to obtain, if at all. But the B.C.I.R.A. has tried a process involving the addition of a small quantity of titanium to a melt of high-carbon iron (No. 3 hematite iron), and then a treatment of the latter with carbon dioxide. While retaining the high-carbon content the structure obtained is of a fine graphite type approaching that originally suggested.

During its life the composition of the mould material changes somewhat—the total carbon falls (due to decarburisation at the working face); combined carbon falls due to conversion, under heat, of pearlite to ferrite.

Cracks and faults which occur in steel ingots are frequently due to bad mould design. Where, for instance, the section of the wall is too heavy (especially in the case of ingots of small diameter) circumferential cracks may be produced near to the hot top. The metal may, moreover, solidify too quickly, causing the rate of pouring to be increased in order to prevent premature freezing, with the consequent ill-effects on the structure and internal soundness. With thick moulds their life may be prolonged as a whole, but in the long run great age and the temptation to use the moulds beyond an economic limit may be a disadvantage, giving cracks—or hangers—on the internal surface, and this yields faulty ingots. Recent results in steel practice have shown that, generally speaking, with moulds made from similar classes of iron, thick walls fail by disintegration of the surface and give a low total weight of ingot per unit weight of mould metal. As the thickness decreases a figure is reached at which this latter ratio attains a maximum value, afterwards decreasing, and the tendency to major cracking increasing, as the wall thickness becomes less.

The cooling of a casting within a mould is a thermal operation, involving considerations of thermal conductivity, specific heat and density of the mould. It should be as uniform as possible, consistent with the heat being removed quickly in order to give rapid chilling. In the old type of hematite iron box this could not readily be obtained because of the high thermal resistivity and low heat capacity of the material and because also of its complex internal structure. Thoughts then turned to other materials, particularly copper.

The Use of Copper Moulds

In order to obtain the highest efficiency from copper moulds the copper itself should be of high purity, otherwise the conductivity is considerably diminished and the essential advantage is lost. For instance, 0.4 per cent. As, 0.15 per cent. P or 1 to 2 per cent. Sn reduces the thermal conductivity by over 50 per cent. The thickness of the walls should be sufficient to carry away enough heat, aided possibly by circulating water, to maintain the inner face cool and keep pace with the rate of heat outflow. If such means are not provided welding of the molten metal on to the copper will ensue. The danger is greater with the higher melting-point alloys and therefore the counter provision must be more extensive and water-cooling is imperative. With lower melting-point alloys, non-water-cooled moulds are employed and are adequate for removing quickly the smaller amount of heat in the molten mass. It may also be noted that there is a considerable decrease in the amount of heat transferred to the water-cooled copper mould once it is filled, for by that time the ingot is solid and has shrunk, leaving an air gap which acts as an insulator. At the same time, however, the ingot may safely be withdrawn much sooner, while it is exceedingly hot, thus lessening the working cycle.

A comparison between cast-iron and copper moulds on similar types of work may be summarised as follows:—

	Cast iron.	Water-cooled copper.
(1) *Life* ..	Replacement after about 1,000 heats. (They might, however, be re-machined for the next larger size.)	Copper lining renewed after 3,000 to 5,000 heats. Instances have occurred up to 15,000 heats.
(2) *Casting cycle*	10 mins.	2 mins.
(3) *Lay-out*	Each casting unit requires up to six moulds because of preparatory work (heating up, etc.).	One mould will serve two or three casting units. Minimum of preparation.
(4) *Structure*	Beyond any adequate control.	Uniform structure. Surface does not require machining.

A further advantage of the copper mould is that it is only slightly elastic but very ductile. Any strains, therefore, which are produced during casting are relieved by normal plastic flow on cooling.

The Erical Process

Of almost opposite character to the copper mould is the one designed by Ericsson and used in the Erical process of casting. In place of high-conductivity copper Ericsson uses low-conductivity nickel iron which has also low thermal expansion. Hence the solidification rate is much lower, the temperature gradient through the mould wall is steeper and the difference between the temperature on the front and back of the mould is considerable. Due to expansion, the wall becomes slightly convex inwards and the face pressure thus exerted forces the metal which is still molten in the centre up into the pipe cavity above, thus yielding a larger percentage of sound metal.

In addition, piping is avoided without the necessity, or inconvenience, of feeding in, and a fine structure is obtained. Any tendency there may be to crack in the middle constricted region, due to contraction effects within the area restricted by the inward pressure of the plates, may be countered by giving the plates an initial set outwards by means of adjustable screws. The final result is, of course, that the sides of the ingot are almost parallel. A thin clay wash, followed by a thin oil dressing is recommended for the Ericsson mould. The latter is also provided with an accurately centred tun dish.

It is recognised, as will be shown later, that casting in normal practice is accompanied by much turbulence of the molten metal. Bottom or upward casting, such as is widely practised in the case of steel, wherein the metal is fed down a feeding tube, along a horizontal channel and then up into one or more moulds, reduces this factor considerably but not entirely.

The Durville Casting Method

The most successful attempt to overcome turbulence is the Durville method in which, in effect, the mould slips round the molten metal instead of the latter splashing into the mould. In this process, used principally for copper-aluminium alloys, the metal from the melting furnace is transferred via a hand-carried ladle to a container which is attached permanently to the mould. The metal is carefully skimmed and the mould and container then rotated around a horizontal axis until their positions have been reversed.

Mould Dressings

Mould dressings are common in all classes of ingot casting. The functions of a dressing may be summarised as follow:—

(1) To prevent the molten metal from adhering to the mould material by providing a protective film.

(2) To enable the ingot to be removed easily when solid.

(3) To assist in providing a reducing atmosphere as far as possible during the transit of the molten stream down the mould.

(4) To afford lubrication.

Of the many types of dressing none is ideally suitable to meet all circumstances and, indeed, one generally finds a pet nostrum in every foundry. In the common mixtures oil of some kind or another finds a large place. Refractory inorganic washes are mostly confined to ferrous practice. In any case, there should be no reaction between the dressing and any constituent of the ingot or mould.

One point about which there is doubt is the desirability of having a heavy oil with a high flash-point which will not readily ignite or decompose, or a light oil with a comparatively low flash-point so that it will burn easily as the metal rises in the mould. The deposition of much soot or carbonaceous deposit from a fully cracked oil is to be deprecated, as this gives rise to blemishes on the bar surface. In general, experience seems to point to the use of a light dressing of a heavy oil, either alone or in mixtures, for most non-ferrous work. There is no clearly defined preference for a mineral as against a vegetable oil.

Common dressings include lard oil, olive oil, melted resin, mixtures of graphite and lard oil; graphite and olive oil; resin and turpentine; tallow, resin and turpentine, and a well-known one consists of lard oil, tallow, china clay and french chalk in the proportion 3 : 2 : 1 : ½ and finally stiffened by the addition of graphite.

Genders and Bailey found that a volatile dressing causes in general a decrease in crystal size, an increase in the columnar crystallisation normal to the mould face and an increase in depth of the layer of chill crystals between the mould and the columnar ones. Volatile dressings have, moreover, the disadvantage of giving off gaseous products which may become entrapped or dissolved in the metal. Porosity thus produced is mostly just under the skin. In instances where the metal solidifies before all the dressing has volatilised—*i.e.*, mostly in narrow moulds—contraction cavities are prevalent. In larger moulds the passing of the escaping gases tends to promote greater temperature distribution, and therefore more uniform cooling, coupled with a more extensive dispersion of gas porosity.

Soot from burning acetylene or turpentine has been recommended, but in personal experience, so far as strip casting is concerned, has proved ineffective. Such a soot dressing is in reality inferior to the usual oil as a thermal insulator. As a result, local heating and blowing may occur, especially if the metal impinges on the mould side.

For cupro-nickel and similar high melting-point alloys, lard oil mixed with a little fine graphite appears to be effective, and if the alloy is being cast into thin strip ingots a little dry graphite scattered over the mouth of the moulds after the primary dressing prevents sticking at that point and promotes the formation of a better and more economical top to the ingot. For precious metals simple lard oil or olive oil without admixture is effective.

Mould Dressings for Ferrous Work

In ferrous work washes of finely ground clay, or ganister, with and without frequent applications of oil, oil and graphite, etc., are commonly used. A wash containing a mixture of carborundum and fireclay powders in the proportions of about 6 : 1 has also been employed. Clay-washed moulds have a tendency to flake at temperatures exceeding 300 to 350 deg. C. The application of oil alone or mixed with graphite increases the life and reduces sticking appreciably. Such a coating would operate up to a mould temperature of about 400 deg. C. A mixture of kaolin and water-glass would appear to have advantages, but unfortunately it tends to flake readily. A few drops of machine oil from a can immediately before casting is very effective.

General Considerations

The subject of ingot casting cannot be confined solely to the actual methods which are adopted. Some consideration must be given to the processes that are operative within the metal during pouring and solidification. The physical and chemical laws which are invoked work in many diverse ways that are even now but imperfectly understood. A number of observed facts, however, merit close attention.

Perhaps the most significant observation is that during casting the molten metal is in a state of turbulence. If it were possible to transfer molten metal from crucible to mould without such turbulence much of the foundryman's trouble would be solved. Transference imposes difficulties of its own and to their suppression much ingenuity has been applied. The nearest approach to quiescence is in the Durville process, and in those rare instances, *e.g.*, in accurate precious-metal work where the material is melted and allowed to solidify in the same crucible or in a special type of electric furnace, yet in each of these instances there must almost inevitably be some disturbance due to convection currents. The production of a sound casting depends primarily on the union of moving molten particles. Ideally, each layer in succession should coalesce with the nearly solidified layer preceding it, and thus gradually fill the mould. In other words, the bottom part should be solid before the casting is completed. If sand moulds are used the transfer of heat through the walls is so small that it is difficult to pour slowly enough for this state to arise, and indeed it may not be desirable. In actual fact, what happens?

(1) The incoming metal causes that already within the mould to rise, by simple pressure, basin shape towards the side. The stream also acts as a minor injector drawing air in with it which disperses as bubbles. These effects are accentuated when a single stream is used. Where, however, a tun dish is employed, and the metal flows in in several smaller streams, though the total force may be the same it is distributed, and displacement and splashing are on a much lesser scale, giving a secondary but important effect of more uniform temperature, while the injector effect is considerably reduced. Time in feeding is also saved, less care is needed to fill the mould, the top end waste is a minimum and there is an increase in the general soundness of the ingot. In bottom or upward casting, too, there is little lateral displacement. Both these devices result in much more equable conditions throughout the ingot.

(2) Crystallisation commences from the mould, first as small, regular equiaxed crystals then as columnar ones, and finally in the interior, small crystals again form. This change of crystalline form has been variously attributed to (*a*) undercooling; (*b*) the separation of the ingot from the mould due to contraction; (*c*) the attainment by the mould of a constant temperature and a consequent decrease in the rate of outflow of heat; (*d*) the overstepping of a critical ratio between the amount of solid crust and the still molten liquid. In general the higher the casting temperature the higher is the temperature gradient and the longer become the columnar crystals. The longer the solidification range the greater the relative amount of equiaxed crystals.

(3) As solidification proceeds, contraction occurs simultaneously: (*a*) of the cooling liquid metal (this can be minimised by attention to feeding and pouring temperatures); (*b*) during the transition from solid to liquid, and (*c*) of the solidified material.

(4) The still liquid metal flows, as far as it is able, having regard to the obstruction offered by the growing crystals, into the gaps still left, including those small ones produced by the contraction of the material already within.

(5) The last of the liquid solidifies and contracts, giving the usual pipe in the upper part which may or may not be bridged by solid matter excessively quickly cooled by exposure to the atmosphere. Contraction cavities form more readily in long, thin ingots than in thick, fat ones. If feeding is not continuous, other deep-seated cavities may be left to which the feed has not penetrated.

It is advantageous in chill ingot casting to induce chilling from the bottom. To this end large copper blocks have been used as bases for steel ingot moulds, thus conducting the heat away quickly. One of the most important results arising from the use of copper stools in the casting of steel ingots is the increased life of the cast-iron moulds. Such blocks have also been used for casting nickel alloys. In all cases advantages lie in ensuring solidification from the bottom. A process—R.W.R.—has also been developed on the Continent in which, after the metal has filled the mould, a water-cooled copper plate is fixed over the top and then the whole assembly is inverted so that the copper plate is at the bottom during solidification.

There is, then, a general picture; but it does not illustrate the whole story, for, in addition, there are:—(1) The presence of gases—dissolved, entrapped from the atmosphere or derived from the mould dressing; (2) the segregation of impurities either at the crystal boundaries or in the last metal to solidify down the centre, whither they are forced by the solidifying metal which rejects them; (3) the movement of some constituents in certain alloys inward or outward, according to apparently regular laws (though the mechanism is still a matter of controversy), which is termed variously segregation, inverse segregation (if the movement is contrary to what might be expected from normal solidification) or liquation. This results in enrichment of the ingot as regards a particular constituent at one part and an impoverishment at another.

Molten metals dissolve gases in increasing amount with an increase in temperature, and much gas is also entangled mechanically. Further, there may be chemical combination between the furnace gases and some gas already in the metal. For instance, Allen has shown that hydrogen from flue gases readily combines with oxygen in the cuprous oxide in copper to yield steam to which the ultimate unsoundness is due in great measure. As the temperature falls a certain amount of gas is liberated, and on solidification evolution is very active. A certain amount of the residual gas is driven into the central portion of the ingot, some is distributed in minute globules, but with a concentration just under the outer skin, and some may remain, in an unsound ingot, in large cavities in the metal, probably causing blisters during subsequent rolling and annealing. Moreover, in their formation they displace liquid metal, and thus reduce the size of the shrinkage cavity itself.

The reduction of the gas content of ingots has been widely investigated, and among the processes found effective to a certain degree are:—

(1) Control of pouring temperature and rate of pouring. In general, unsoundness in an ingot is the additive effect of contraction and gas content, and depends largely on the casting temperature and the rate of pouring. A measure of super heat in the molten metal is desirable, and on the whole it is better to err in having the melt too hot than too cold, provided it is combined with a slow rate of pouring. Usually soundness increases as the rate of pouring decreases, but with too low a casting temperature unsoundness results whether the pouring rate be fast or slow. The measurement of density is a good criterion of soundness.

(2) Deoxidation.

(3) Rapid stirring, especially with a graphite rod.

(4) Allowing the melt to solidify in the crucible, thus passing through the most active gas evolution stage, then remelting it again quickly and casting.

(5) Introducing the vapour of volatile chlorides or the chlorides themselves. For aluminium castings chlorine, boron trichloride and titanium-tetrachloride have been used.

(6) Passing a neutral gas, *e.g.*, nitrogen, though the melt, which results in the contained gas being driven out. Perfectly sound piped ingots have been obtained in this manner from unsound aluminium and killed steel.

(7) Melting as a last refining operation and casting *in vacuo*.

The last, which has attained some prominence on the Continent, relies partly upon the withdrawal of the gases under reduced pressure of 2 to 5 mm. of Hg., partly on the ordinary evolution of gas during solidification, and partly on the dissociation of gases chemically combined with the metal under the influence of temperature and reduced pressure. It permits the melts to remain quiescent for unlimited periods out of contact with the air, allowing full deoxidation to take place and solid contaminating impurities to

rise to the surface. It is costly, and although large furnaces *have* been built, their use is confined to the treatment of material whose ultimate value in a de-gassed state warrants the expense. The furnace used is of the low-frequency induction type, and the charge is slowly heated to the melting temperature in 6 to 7 hrs. It is then allowed to become completely liquid at a temperature not much above the melting point during 2 to 3 hrs. Much gas is given off during this period, and then the temperature is raised considerably—in the case of steel to 1,700 deg. C.—and maintained at that point for 6 to 8 hrs., during which the principal and final refining occurs. Subsequently the temperature is allowed to fall again nearly to the melting point and the metal is cast into ingots, still under the influence of the vacuum and of the heating medium. In this manner a small controlled stream of degassed metal may be poured into a mould out of contact with air or other gases, and at such a rate that it follows up the metal just solidifying, thus being allowed to fill any gross or even intercrystalline cavities. For ingots weighing 700 lbs. and 4 tons casting times of 15 min. and 40 to 60 min. respectively have been employed.

Such special methods have the possibility of only a limited field. For general work reliance must still be placed on simple modifications which can readily be adapted. These in the main are:—

(1) The use of copper moulds and vertical central feeding from a tun dish arrangement.

(2) Bottom pouring (although this is partially supplied by the tun dish).

(3) Quick transit of the metal into the mould at a relatively high temperature.

(4) The lowest possible amount of dressing on the mould.

(5) Protection of the stream of metal from atmospheric contamination, *e.g.*, by a ring of flame.

Segregation, as has already been indicated, may occur in three ways:—(1) Of impurities to the centre or at the crystal boundaries where the effect is to reduce the mechanical strength of the material; (2) general dispersion throughout the mass; some impurities may actually be dissolved; and (3) of certain constituents—towards the interior or towards the outside.

Flowing Power

Unclean metal may arise from the doubtful character of the original charge, especially if secondary metals have been used, or from oxidation during the pouring operation. The films of oxides—or nitrides—formed on the melt and on the pouring stream when such constituents as Al, Mg and Zn are in the charge, cause an apparent increase in the viscosity of the liquid, though this, in reality, is not the case, for the viscosity of molten metals is little greater than that of water. The fall of the film into the mould as it breaks off at once introduces foreign material which has a deleterious effect, preventing coalescence. Moreover, that characteristic which has been variously termed fluidity and castability, but is perhaps better called flowing power or "flowability," is prevented from having full play in the mould, resulting in imperfect surfaces and internal contamination. In good work nothing should prevent the even flow of liquid metal into the portion which is solidifying. Another cause of an apparently thickened stream is the presence of a large quantity of gas which is restrained by the surface tension of the liquid metal and has had no opportunity of being released.

In some cases the oxide or nitride is soluble in the basis metal, as in copper, nickel and iron, and there is then every chance of the metal pouring cleanly although the oxides are still entangled in the stream. If perchance a flux is

(*Concluded in next column.*)

(*Concluded from previous column.*)

used or the product of deoxidation, say with phosphorus, has a low melting-point, then the film is carried almost invisibly on the surface of the stream as a fluid layer.

Generally speaking, flowability is greatest for single metals and eutectics. It varies with the extent of the solidification interval, *i.e.*, between the time the metal just starts to solidify and the end of solidification.

In general, the segregation of impurities and undissolved material is towards the centre of the ingot, having been rejected by the growing crystals. Some, however, becomes entangled and remains in the main body of the ingot. The aim is so to disperse these small quantities of foreign matter that they become innocuous or else, if in large quantity, to gather them together in the last portions to solidify when they may be removed. There is a tendency for the metal solidifying in the central portion to draw the impure liquid down by the force of contraction and thus yield an impure region some way down the ingot.

The so-called inverse segregation has been attributed to the flow of still liquid metal between the dendritic crystals, to the operation of gases within the metal, and to the repulsion of primary crystals away from the chill surface. Whatever be the true explanation the results may be expressed quite simply—the enrichment at the surface of the ingot of that constituent which solidifies last and not, as one might expect, of that which solidifies first. The enrichment in the interior, on the other hand, is of that constituent which solidifies first. Differences in assay between centre and outside, amounting to 2 to 3 per cent., have been observed, especially in low-grade silver alloys. Such differences do not normally give rise to any serious difficulties in working, but must certainly be taken into account in sampling and in the manufacture of alloys to close specifications as regards composition.

Refined Pig-Iron, Chilled Grit and Pre-Cast Concrete

DARLASTON IRON WORKS VISITED

Last Thursday, a representative party of the Institute of Vitreous Enamellers accepted an invitation to inspect the works of Bradley & Foster, Limited, of Darlaston. The visitors were welcomed by Mr. J. E. Hurst, technical director, who apologised for the absence of Mr. Lunt, the managing director, who had at the last minute been called away for a business appointment.

Mr. Hurst explained that the business of the concern was divided in four main departments—the manufacture of refined irons, the making of chilled iron abrasives, the heat-treating of components for the trade, and the manufacture of pre-cast concrete and cast stone.

Under the leadership of Mr. J. H. D. Bradshaw, the party then left for a tour of inspection of the works.

Refined Pig-Iron

This department melts the raw materials in two 10-ton an hour cupolas, working on alternate days. Metallic raw materials are unloaded from the wagons by an electro magnet, and transferred to hoppers resting on scale cars, where, with limestone, everything is meticulously weighed and recorded. The hoppers, which are of the automatic bottom-discharge variety, are attached by hook to an overhead gantry. A button is pressed, the hopper raised into the air, racked out in the cupola charging door, lowered so as to release the burden, lifted up, racked in and lowered back on to the scale car, all these operations being entirely automatic. The metal feeds an oil-fired receiver of the Hurst type, and when something of the order of ten tons has accumulated, a locomotive takes the receiver to the mixing and degassifying plant. Here, the metal roof of the receiver having been removed, four rods of varying length covered with sleeves and a stopper end, much after the type of the arrangement used in connection with a bottom-pouring ladle, are lowered and rapidly rotated for five minutes. Now that oxygen determinations are available and reliable it will soon be possible to substantiate the not extravagant claim that the gas content is reduced, but in any case it is obviously extremely advantageous in assuring regularity of composition of any one particular cast, especially when the incorporation of alloys is a feature. After stirring, the locomotive returns the receiver to the position beneath the cupola, and the metal is tapped into the pig beds. A chill casting machine has been installed, but was not in operation at the time of the visit.

Chilled Iron Grit Manufacture

The cupola for melting the metallic charges is also automatically charged, but in this case the inclined plane system is used. The stream of the liquid metal is quenched by encountering controlled blasts of air, water and/or steam, according to the nature of product required. The gravitated material falls into a tank of water, and at a point opposite the cupola, that is against the shop wall, it is transferred by a bucket elevator to a rotary drier. This automatically discharges the material into the boot of an elevator which fills a storage hopper. From the hopper the material is fed into a ball grinding mill, where it is crushed to the sizes required by industry in general. Each section of industry or, indeed, different works using the same process, demand a particular size of grit. To effect this separation, the material is conveyed to a nest of vibrating screens, and from each compartment there is a lead-off to fill a line of hoppers, situated at a convenient height for bagging.

Control System

Between the grit manufacturing department and the laboratories, a quick inspection was made of the heat-treatment department. Here, replete with batteries of electric and town's-gas furnaces, a service is given to the forges and foundries of the locality for carrying out the many and varied thermal changes required by modern industry.

The laboratories immediately indicate to the visitor that this is a metallurgical establishment of large dimensions. They are particularly well equipped for the complete control of the chemical and physical properties of the raw materials and finished products. A special feature is the hardness control of the abrasives manufactured. The micro-laboratory is particularly well appointed.

Pre-Cast Concrete

This department, which is very extensive, was obviously of less interest, but presented a number of features, such as finish and colour, which aroused favourable comment by the visitors.

Vote of Thanks

After tea had been taken in the staff dining room, Mr. W. Todd, a vice-chairman of the Institute, proposed a vote of thanks to the directors for their kindness in opening the works for inspection. Though the firm and its antecedents were so old as to be of historic interest, this was, he learnt, the first occasion upon which there had been an official inspection. Moreover, he believed that this was also the first time that a plant making chilled iron grit had been demonstrated to the public.

Mr. V. C. Faulkner, chairman of the London Section, in seconding, emphasised the indebtedness of the visitors to the staff for acting as guides. Mr. Bradshaw, of the technical sales staff, replied.

Composition and Microstructure of Ancient Iron Castings*

By MAURICE L. PINEL, THOMAS T. READ and THOMAS A. WRIGHT

The erroneous, but until recently widely prevalent, belief that iron castings were first made in Europe in the fourteenth century has been adequately refuted in a number of earlier Papers,[1] [11] [12] but except for an unpublished metallographic study by the late William Campbell, and a phosphorus analysis by T. A. Wright of the metal of the Han dynasty cast-iron stove described by Laufer,[2] nothing was known of either the chemical composition or the metallographic structure of the metal of any ancient iron casting, although data on castings of recent manufacture are abundantly available. The metal of the stove, which had been buried in a grave for at least 15 centuries, was so corroded that it seemed inadvisable to publish the results on it until more and better specimens from other ancient castings could be obtained.

During a journey through China, extending from Peking in the north to Canton in the south and Cheng-tu, Ssu-chuan, in the west, in the late summer and autumn of 1936, one of the authors (T. T. Read) was fortunate enough to obtain, and bring home for study, nine castings, all more than 1,000 years old, of which the date of manufacture is precisely known, because of inscriptions cast in them, another that lacks a dated inscription, but of which the date, as explained below, can be otherwise established, and a specimen from the largest iron casting ever made,[11] which is also dated. The period covered by this suite of specimens extends from 502 to 1093 A.D. In addition, a sample was obtained from a casting of date unknown, but which was certainly cast before 1000 A.D., and possibly as early as the third century A.D.

A detailed description of these specimens is as follows:—

(1) 502 A.D. A pair (right and left) of recumbent lions (Fig. 1). Base 7¼ by 14⅜ in., height over-all 5½ in., weight 26 lbs. each. The translation of the inscription on the base is: "Made on the twenty-fourth day of the seventh month of the third year of Ching Ming of Great Wei" (September 11, 502 A.D.).

(2) 508 A.D. Two cast-iron ink slabs, ⅞ by 4 by 5¾ in., weight 4½ lbs. each. The obverse bears the inscription: "Yung Ping Seven Star Ink Slab." The reverse shows the constellation of the Great Bear, with the inscription: "Made under the supervision of Yu Jen in the second month of Spring of Ping Shen" (March, 508).

(3) 550 A.D. A standing figure of Kwan Yin, on a 7½ by 3¼-in. round (lotus) pedestal, the overall height being 31 in. and the weight 50 lbs. (Fig. 1). The inscription on the front of the base is: "An image respectfully made by Cheng Wen for his parents at Cloud Light temple, Bell Rock Mountain, on the twenty-eighth day of the third month of the first year of Tien Pao" (April 30, 550 A.D.).

(4) 558 A.D. Small standing figure of Kwan Yin (Fig. 1) on a rectangular base, the over-all height being 20 in. and the weight 16 lbs. On the reverse of the halo about the head is the inscription: "This iron image was made on the twenty-fifth day of the ninth month of the sixteenth year of Wu Ting (October 22, 558 A.D.) above for the Emperor and after him for the multitude of lives."

(4B) 719 A.D. A panel 18¼ in. square showing three figures (Fig. 2), a central Buddha and two attendants, each standing on a lotus pedestal. Weight 52 lbs. No sample was cut from this specimen, as it was impossible to obtain one without defacing it. The inscription is: "Made on the ninth day of the third month of the sixth year of Kai Yüan, Great Tang" (April 4, 719 A.D.).

(5) 923 A.D. Two panels (Fig. 2). One similar in design to 4B is 13¼ by 17½ in. and weighs 25 lbs.; the sample is from this one; the other (shown in Fig. 2), with only two standing figures, is 9½ by 19 in. and weighs 25 lbs. Each bears the same inscription: "An image respectfully made by monks of the Old Buddha temple on the ninth day of the tenth month of the second year of Tung Kwang of Great Tang" (November 20, 923 A.D.).

(6) 953 A.D. Sample from 20 by 16-ft. cast-iron lion at Ts'ang-chow. (See ref. 11 for detailed description.)

(7) 1093. One of 1024 cast-iron panels, 7¼ by 7¾ in., from a pagoda built at Chü-Yüng (26 miles east of Nanking) in 1093 (Fig. 2). Weight 6 lbs. The inscription says: "Given by Mrs. Hsü, a female disciple of this province."

(8) ? Date. Sample from "flying scissors." Nanking (Fig. 3). Date unknown, certainly earlier than No. 7, and perhaps as early as 300 A.D.

(9) ? Date. Sample from cast-iron stove.[2]. Almost certainly older than 200 A.D.

FIG. 1.—LEFT TO RIGHT: No. 1, 502 A.D.; No. 3, 550 A.D.; No. 4, 558 A.D.

FIG. 2.—LEFT TO RIGHT: No. 4B, 719 A.D.; No. 5, 923 A.D.; No. 7, 1093 A.D.

FIG. 3.—FLYING SCISSORS, NANKING. SPECIMEN NO. 8.

"Flying Scissors"

As nothing has hitherto been published in English about the casting represented by sample No. 8, a brief description seems necessary. This casting, shaped like an X, 3 by 6 ft., and weighing about 1,500 lbs., has been described by Louis Gaillard ("Variétés Sinologiques," Shanghai, 1904) as well as two other similar ones. The purpose of all three is completely unknown. Chinese writings generally ascribe a third century date to one of them, but there is nothing more definite about the one from which the sample was obtained than a remark by a fourteenth century Chinese author, who said it was so old at that time that no one any longer knew when it was made or for what purpose. It has been included in the suite because of the considerable probability that it represents a date intermediate between No. 1 and No. 9, the latter being the earliest specimen of iron casting so far discovered. No. 1 is the earliest precisely dated iron casting known to exist.

As to the authenticity of these castings, there can be no doubt as to No. 6, as it was taken by one of the authors (T. T. Read) and the date cast into the lion is supported by documentary evidence as well. Nor is there question as to No. 7, as it was removed from the pagoda under personal supervision. It was evidently built into the pagoda at the time of its original construction, and the date of 1093 A.D. for the latter is amply supported by historical records.

Nos. 1, 2, 3, 4, 4B and 5 have their dates cast in them, and the only question is whether they might possibly be later reproductions of originals that have been lost. The inferences on this point drawn from the analyses and study

* Extracts from a Paper read before the American Institute of Mining and Metallurgical Engineers. The authors are respectively, Metallurgist, with A. W. Deller, Patent Attorney, New York, N.Y.; Vinton Professor of Mining Engineering, Columbia University, New York; and Secretary and Technical Director, Lucius Pitkin & Co., New York, N.Y.

of the microstructure will be discussed later; it is only necessary to say here that these castings were purchased from curio dealers, or private individuals, in Nanking for prices so small that no one could have made a profit by duplicating an original. The Chinese are not interested in old iron castings, there is no market for them, and where they can be obtained at all it is practically at the price of scrap iron. The inscriptions on Nos. 3, 4, 4B and 5 conclude with two Chinese characters that mean that they were the only pieces cast from that mould. Without going into further details, the authors feel confident that these castings are original specimens made at the dates given.

Only No. 3 has in its inscription a place name, and unfortunately it defies identification. It can be merely inference that the castings, obtained at Nanking in 1936, were originally made somewhere near there. The lion at Ts'ang-chow (No. 6) is about 450 miles north of Nanking and was, of course, cast where it now is. Iron would be easily available there from the near-by province of Shantung, which was certainly one of the earliest iron-producing regions of China, a proposal having been made to tax iron there in the seventh century B.C. "Buddhist Monuments of China" by Tokiwa and Sekino shows illustrations of cast-iron pagodas, at various places, mostly with tenth and eleventh century dates.

No. 9 came from about 250 miles west of No. 6. The third of the "flying scissors" referred to under No. 8 is at Kian-fu, 425 miles south-west of Nanking, and must have been made locally. This, and other evidence that need not be set forth here, indicates clearly that the casting of iron was an art that was widely practised throughout China at the time these castings were made. It was an art that was perhaps already at least 1,000 years old at the time No. 1 was cast.

Samples were cut from the castings, milled to provide fine cuttings for the analyses, and pieces for polishing and metallographic study produced. Except from Nos. 2 and 4B it was possible to cut fairly large sections from flanges or other hidden parts without destroying the appearance of the castings. The authenticity of the two specimens numbered 2 was at first doubted and a large segment was cut out of one of the slabs. Both the analysis and the microstructure indicate that these two specimens are also genuine. The results of the chemical analyses are given in Table I.

TABLE I.—*Chemical Analyses of Specimens.*

Specimen No.	T.C. Per cent.	C.C. Per cent.	Gr. Per cent.	Si. Per cent.	Mn. Per cent.	S. Per cent.	P. Per cent.
1	3.35	1.05	2.30	2.42	0.13	0.067	0.205
2	3.22	0.96	2.26	2.39	0.23	0.077	0.17
3	3.35	0.33	3.02	1.98	0.78	0.063	0.312
4	3.33	0.16	3.17	2.12	0.64	0.064	0.186
5	3.12	*	3.12	2.07	0.81	0.053	0.297
6	3.96	3.35	0.61	0.09	*	0.022	0.231
7	3.58	3.54	0.04	0.16	0.25	0.024	0.134
8	3.84	1.49	2.35	0.08	0.02	0.024	0.097
9	†	†	†	†	†	†	0.124

* Not found. † No data.

Spectrographic Analysis

The aim of spectrographic analysis was to determine whether germanium, copper, chromium, nickel, antimony and anything unusual was present in these castings. At the same time any major compositional differences, as disclosed by direct arcing in graphite in position 4 of the B. & L. Lithrow spectrograph, covering the spectral range from 2,600 to 3,800 were to be observed. The procedure was to burn to completion duplicate portions of 50 mg. each, comparing as usual with an ordinary iron as reference. The results were as follows, using spectral lines as shown in Angstrom Units:—

Manganese.—All samples contained manganese (2,794.8, 2,798.3, 2,801.1) in the amount commonly present in ordinary iron, but Nos. 1 and 2 less than Nos. 3, 4 and 5, and Nos. 6 and 8 much less than the others, No. 6 containing the least.

Titanium. — Titanium (2,933.06, 3,072.92, 3088.03, 3,234.52, 3,241.989, 3,349.44) was present in all samples, but much less was present in Nos. 6 and 8. (Note possible interference from iron 3,234.621 and silicon 3,241.67.)

Copper.—Copper (2,824, 3,247, 3,274) was present in all samples, but No. 6 contained more than the others (estimated as 0.06 per cent.).

Magnesium. — Magnesium (2,803, 2,852) was present in all samples, but much more was present in Nos. 6 and 8 than in the other five.

TABLE II.—*Qualitative Spectrographic Estimates.**

Sample No.	1	2	3	4	5	6	7	8
Manganese	++	++	{+++ +++}	+++ +++	{+++ +++}	+	+++	++
Titanium	+++	+++	+++	+++	+++	+	+++	+
Copper	+	+	+	+	+	++ (0.06 per cent.)	+	+
Magnesium	+	+	+	+	+	+++	{+++ +++}	+++
Germanium	+	+	+	+	+	(+)	+	(+)
Nickel	N.F.†	N.F.	N.F.	N.F.	N.F.	(+)	+	N.F.
Cobalt	N.F.	N.F.	N.F.	N.F.	N.F.	++	+	N.F.
Silicon	Appreciable, ± 2 per cent.)					+	appr.	+
Vanadium	+	+	+	+	+	+	+	+
Chromium	+	+	+	+	+	+	+	+
Aluminium	+	+	+	+	+	+	+	+
Antimony	Not found in any							
Molybdenum	Not found in any							
Tungsten	Not found in any except No. 7						+	
Tin	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	{+++ +++}	N.F.
Silver	N.F.	N.F.	N.F.	N.F.	N.F.	N.F.	+	N.F.

* Read for each element alone. Amounts cannot be compared. † Not found.

Germanium.—Samples 1 to 5 inclusive contained a trace of germanium (2,651.15, 2,651.60), but it was barely discernible in Nos. 6 and 8, *i.e.*, spectrographic traces.

Nickel.—Nickel (3,101.6, 3,101.9) was not found except in No. 6, which showed a trace estimated as less than 0.004 per cent.

Cobalt.—Cobalt (3,044) also was present in No. 6 only.

Silicon.—Silicon (2,631.28, 2,881.59) was present in all samples, but very much less in Nos. 6 and 8.

Vanadium. — Vanadium (3,118.383, 3,120.14, 3,125.288, 3,126.21) was found in all samples.

Chromium.—Chromium (2,835.64, 2,843.35) was present in all samples.

Aluminium.—Aluminium (3,082, 3,092) was present in all samples, but more was present in samples 6 and 8 than the others.

Antimony. — Antimony 2,877.92, 3,029.80, 3,232.52, 3,267.48) was not found in any samples but is not very sensitive.

Molybdenum.—No evidence of the strongest (10) lines of molybdenum could be found even in clear regions free of any background.

Tungsten.—No evidence of any tungsten was seen.

Phosphorus.—Phosphorus (2,554.9, 2,553.3, 2,535.6, 2,534.0) could be determined but is given in Table I. This element is very insensitive in an iron matrix.

The above information has been included in Table II. This tabulation is a result of some further rechecking with weighted indications of the relative distribution of each element in the various samples. These indications are intended to be read horizontally only and apply only to the respective elements, which should not, therefore, be compared with each other as to amounts present. Arsenic, because of low sensitivity, could not be determined.

Summary

The metallographic study of these ancient Chinese castings revealed a wide diversity of structures. White, grey and mottled irons were illustrated. Since most of these castings merely served ornamental purposes, the Chinese were undoubtedly only seeking good impressions. In this connection it is interesting to note the relatively low phosphorus content. One of the authors (M. L. Pinel) had occasion some time ago to examine a Chinese coin of the early eleventh century, which contained 0.52 per cent. phosphorus. Another of the authors has reported[1] its present-day use in large amounts in Shansi for the making of thin castings.

Castings 1 to 5 were grey iron, Nos. 1 and 2 being pearlitic and the others containing ferrite in various amounts. The graphite flakes are small and should be expected in thin castings. On the other hand, Nos. 6 to 9 were white or mottled cast irons, Nos. 6 and 9 being somewhat similar except for the presence of some mottled iron areas in No. 6. Whereas the latter were hypereutectic, No. 7 was definitely hypoeutectic. No. 8 was a mottled iron structurally between grey and white irons. The variations in the structure and in the analyses of each of the castings tend to confirm their authenticity. In addition, the castings all showed the effects of weathering, particularly Nos. 7 and 4.

Castings 1 to 5, grey irons, were undoubtedly cast in sand moulds. Most of them tell the exact day of casting, and three had cast into them a sign which indicated that only one piece was cast. There would be no need for permanent moulds.

No. 7, a small casting similar in size to the grey castings, was one of 1,024 such panels. The natural thing in this case would be to use some sort of a permanent mould. The white-iron structure indicates that this is undoubtedly the way in which it was cast. The design would easily permit such practice.

ADDENDUM

By Professor T. T. Read.

During the preparation of the foregoing Paper questions have been asked that involve the expression of opinions for which the co-authors should not be held in any way responsible. In

response to various questions about the making of moulds, it may be noted that as early as 1400 B.C. the Chinese were making well designed and perfectly executed bronze castings, 2 or 3 ft. in their greatest dimension. It may be inferred therefore that when they first made iron castings they were competent to do any kind of a moulding job that was necessary. The author knows of no evidence that the Chinese ever used the *cire-perdue* method for making iron castings. Persons qualified to judge have expressed the opinion, after inspecting the two lions (No. 1, 502 A.D.), that the lower half of the mould was sculptured in the sand without the use of a pattern. Since several of the inscriptions end with two characters that convey the meaning that only one casting was made of that design, this would be a good method whenever it was practicable. But some of the moulds were obviously built up by using cores. Terra-cotta moulds for the casting of coins were commonly used in China at dates earlier than these castings. The British Museum Catalogue of Chinese Coins (1892) refers to a cast-iron mould for making brass coins, dated 7 to 22 A.D.

REFERENCES.

1 T. T. Read: Trans. A.I.M.E. (1912), **43**, 1–53. Pp. 22 to 25 deal with the production of iron castings in Shansi.
2 Laufer: Field Mus. Nat. Hist. Pub. 192 (Anthr. Ser., vol. 15, No. 2), 79–80. Chicago, 1917.
3 "Iron Ores and Iron Industry of China." Mem. Geol. Survey of China (1921), **A-2**, 297–364.
4 F. A. Foster: "Amer. Machinist" (August 21, 1919), 345–352. Description of Chinese iron foundries.
5 F. A. Foster: "The Foundry" (February 15, 1926), 130–135; (March 1, 1926), 173–177; (March 15, 1926), 220–224. Three articles describing in detail Chinese iron casting at Paotingfu, Chihli, and in Shansi province. Shows photographs of large castings made in 1079 and 1097 A.D.
6 B. March: "Iron in Art." Encyclopedia Britannica, Ed. 14, 1929.
7 O. Vogel: "Eisenkunstguss in Fernen Osten." "Die Giesserei" (1930), **17**, No. 23.
8 B. March: Bull. Detroit Inst. of Arts (November, 1931), 14–16. Detailed description of a Tang dynasty (620–907 A.D.) cast-iron lion's head.
9 T. T. Read: "The Early Casting of Iron." "Geographical Rev." (1934), **24**, 544–554.
10 R. M. Shaw: "Cast Iron." "Iron Age" (January 30, 1936), 24–26.
11 T. T. Read: "The Largest and Oldest Iron Castings." "Iron Age" (April 30, 1936), 18.
12 T. T. Read: "Ancient Chinese Castings." Jnl. Amer. Foundrymen's Assn. (June, 1937).
13 T. T. Read: "Chinese Iron—a Puzzle." Harvard Jnl. Asiatic Studies (December, 1937).

As to the method by which the iron was reduced from the ore, it is difficult even to guess. At one time the author felt sure that the Chinese first reduced Fe_2O_3 to Fe, and then melted the particles of metallic iron in a crucible in a blast-blown furnace,[1] but he now feels uncertain whether that method was used elsewhere than in Shansi, and it seems probable that the metal for these castings was produced not far from where they were obtained. Much more research work on the early history of iron in China needs to be done before it will be possible to speak with much confidence on many points.

It is worth noting that the double-acting box bellows used by the Chinese* is an invention of their own, not found elsewhere in the world. As a piece of blowing equipment it is much superior to the devices elsewhere used in primitive metallurgical processes, and must have greatly facilitated the melting of metal for casting.

As to the built-up large casting (No. 6) the author does not know how the successive layers were made to adhere to each other. The adhesion is far from perfect in places, and deep-seated corrosion has taken place along the joints. As this was merely an art object it was not necessary to obtain strong joints between the successive layers.

The analyses recorded here seem to refute the hypothesis which the author suggested in earlier Papers, that the Chinese had from very early times added phophorus to the iron for casting, in order to obtain a more fluid metal; it is

(Concluded in next column.)

* See A. P. Hommel: "China at Work," 18–21.

(Concluded from previous column.)

not high enough to indicate any deliberate addition. The modern practice of adding it was observed only in Shansi and may be confined to the district where it was seen. It may also be a comparatively late development.

Cast-iron coins have been briefly mentioned in the text above; it may be worth while to record here that there is good evidence that they were made as early as 25 A.D. and were used at various times thereafter. A few hundred yards from No. 6, a fused mass of them (probably resulting from the burning of the temple), that weighed at least several hundred pounds, was personally inspected. Only a few were in good enough condition to decipher the characters that indicated their dates. They appeared to be eighth to tenth century.

Foundry Trades' Equipment and Supplies Association

ANNUAL MEETING

The annual meeting of the Foundry Trades' Equipment and Supplies Association was held at the King Street Club, London, Mr. A. C. Turner presiding. The annual report was submitted, and below are printed extracts therefrom of general interest to the industry.

ANNUAL REPORT FOR YEAR ENDING DECEMBER 31, 1937

This report cannot be held to mark any very great advances upon or changes in the condition and policy of the Association since the close of 1936. The membership roll is reduced by two, leaving the present number at 22 members, and the accounts show that, in a year in which no credit has been taken for any Exhibition revenue, the income just about balances the expenditure.

During the year there were two general meetings, and at these, and also on numerous occasions informally, the possibility and desirability of extending the Association's activities, to which reference was made in the last annual report, have been freely discussed, but up to the present no scheme of anything approaching a concrete nature has been presented for the Association's consideration, nor has any substantial approach been made to devising either a policy for the suggested extension or a means of raising fresh revenue to meet any suggested expenditure.

It appears, therefore, that, as for many years, the Association's *raison d'être* remains the crystallisation of the opinion of the trade from time to time in relation to exhibition policy and the implementing of such policy by agreement with exhibition organisers. In this connection, the year under review witnessed the second occasion of the holding of the Foundry Trades' Exhibition in conjunction with the Engineering and Marine Exhibition at Olympia. Here again the results show no considerable difference from those obtained in 1935. Whilst a substantial Foundry Section of the Olympia Exhibition was again brought into being, it cannot be felt that this constituted a thoroughly representative Foundry Trades' Exhibition, owing largely to the absence of certain of the leading plant and equipment manufacturers.

At the autumn general meeting, held on September 22, 1937, at Olympia, a possible complication of the matter of exhibitions was considered in the report that, in 1939, an International Foundry Conference was due to be held in London under the auspices of the Institute of British Foundrymen. If precedent were followed, that conference would take place in June, and the Association had to decide whether they could arrange with the organisers to embark upon a separate Foundry Exhibition at the Royal Agricultural Hall to coincide with the conference in June or not, and the opinion of that meeting was that it would be financially unsound to revert to the previous practice of holding a separate exhibition, which had had, in fact, to be abandoned owing to the smallness of the trade and consequently lack of sufficient support. It was, therefore, decided to communicate to the Institute of British Foundrymen an invitation to arrange the International Conference in September and to offer them in that event accommodation at Olympia for their official and social functions and then to endeavour to get together a thoroughly representative exhibition of foundry plant and supplies in conjunction with the Engineering Exhibition and with the conference. The authorities responsible for the last-named event could not, however, see their way to depart from their previous practice of holding the convention in June. In view of this, the organisers, with the knowledge of the Association, once again very thoroughly canvassed the possibilities of a separate exhibition, bearing in mind the fact that it would be ten years since the last International Conference was held in London.

The report of that canvass and the consequent attitude of the Association towards the next exhibition had not been discussed at the time of the close of this report; it is, however, fairly obvious that, on account of the small field of potential exhibitors who number foundrymen as their chief customers, no such separate exhibition can be undertaken without the wholehearted support of some 80 per cent. of such potential exhibitors. Whether this will be forthcoming remains to be seen, but, whatever the upshot, the Association does feel that it is extremely important to have in existence a body such as itself, which can undertake such investigations in conjunction with those financially responsible for the exhibition, and which, incidentally, has secured very definite financial advantages to its exhibiting members, and for this reason it hopes that this necessarily somewhat negative kind of report will not discourage its members, but that they will see the wisdom of continuing the existence and functions of the Association and keeping the membership together against future developments of any kind whatsoever.

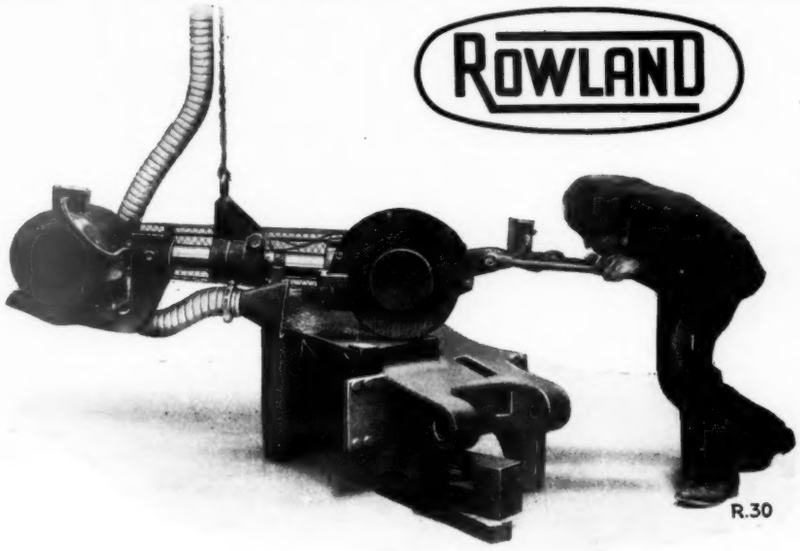
For the rest, a very friendly relationship, both officially and personally, is maintained with the bodies representing other sections of the trade, and the collection of a central fund raised by the Association to be pased to the Institute for the purpose of their annual convention was again successfully undertaken.

The officers were all re-elected, and it was decided to support the Engineering and Marine Exhibition by creating a Foundry Trades' Section in September, 1939.

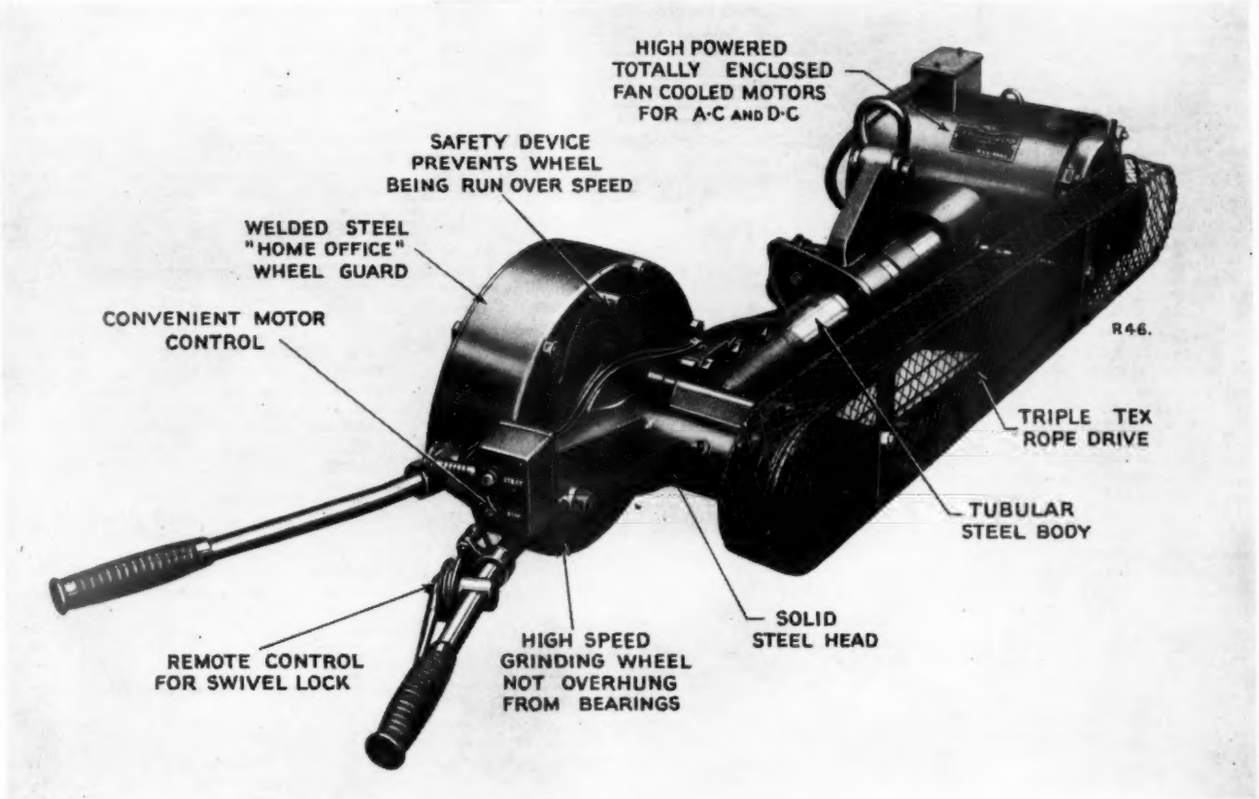
Pig-Iron and Steel Output

The British Iron and Steel Federation report that the production of pig-iron in February amounted to 693,300 tons, compared with 603,700 tons in February, 1937. The output was the highest in the second month of any previous year. It included 155,700 tons of hematite, 383,700 tons of basic, 121,700 tons of foundry, and 14,600 tons of forge pig-iron. There were 124 furnaces in blast at the end of February, compared with 130 furnaces at the end of January, seven furnaces having ceased operations during the month, and one having resumed production after being damped down. Production of steel ingots and castings, at 1,057,600 tons in February compared with 995,900 tons in February, 1937, remained at a high level, and the rate of output per working day substantially exceeded the daily rate recorded in January. Compared with February, 1937, last month's output was 61,700 tons higher, and in no previous year has the February figure exceeded 1,000,000 tons.

ROWLAND



HIGH SPEED PORTABLE GRINDER


HIGH POWERED TOTALLY ENCLOSED FAN COOLED MOTORS FOR A·C AND D·C
SAFETY DEVICE PREVENTS WHEEL BEING RUN OVER SPEED
WELDED STEEL "HOME OFFICE" WHEEL GUARD
CONVENIENT MOTOR CONTROL
R46.
TRIPLE TEX ROPE DRIVE
TUBULAR STEEL BODY
SOLID STEEL HEAD
HIGH SPEED GRINDING WHEEL NOT OVERHUNG FROM BEARINGS
REMOTE CONTROL FOR SWIVEL LOCK

THIS machine can show a greater saving than any other piece of equipment in the Foundry. It is light to handle and the wheel can be used in almost any position. Its all steel construction makes it immensely strong, and other important features are referred to in the illustration. Most important of all the bearings for the grinding wheel are inside the collet so that the wheel does not overhang the bearings.

Send for full particulars.

F. E. ROWLAND & Co., Ltd., CLIMAX WORKS, REDDISH, STOCKPORT.

LONDON: Clyde, Amos & Co., Ltd., 22, Martin Lane, Cannon Street, LONDON, E.C.4. MIDLANDS: L. Williams, Esq., 31, Parkside, COVENTRY.
N.E. COAST: T. Feather, Esq., 16, Devonshire Place, Jesmond, NEWCASTLE-on-TYNE. SCOTLAND: Wilson Feather & Son, 122, Wellington St., GLASGOW.
SHEFFIELD: Gregory & Taylor Ltd., Howard St., SHEFFIELD.
LANCASHIRE, YORKSHIRE & CHESHIRE: Alex. W Maycock, Esq., 15, Lindsay Ave., MANCHESTER, 19.

The Week's News in Brief

Trade Talk

A PATTERN SHED at the works of the Birtley Company, Limited, Birtley, County Durham, was destroyed by fire last week.

THE COMMISSIONER FOR SPECIAL AREAS, Sir George Gillett, opened the Dowlais site of the South Wales and Monmouthshire Trading Estates on March 10.

CROSSLEY MARINE ENGINES, LIMITED, is being wound up voluntarily. Mr. Graham Watson, 2, Lancaster Drive, Prestwich, Manchester, is the liquidator.

THE SKODA WORKS of Prague and Plzen have secured a contract for the construction of three electrical power-stations as part of the scheme of the electrification of south-west Bulgaria.

A 37-TON "Adamite" roll cast in the Whifflet Foundry of R. B. Tennent, Limited, Coatbridge, is being prepared for despatch to Port Talbot, Wales. A second roll, weighing 50 tons, is to be cast in the near future.

IT WAS ANNOUNCED at the annual meeting of the Dudley and Staffordshire Technical College last Thursday that the Earl of Dudley had awarded two scholarships of £30 annually, to be known as The Earl of Dudley Scholarships, to boys of 14 taking the two-year course.

A ROUND-TABLE PUBLIC DISCUSSION on the lighting provisions embodied in the new Factory Act will be held under the auspices of the Industrial Lighting Section of the Illuminating Engineering Society, at the Home Office Industrial Museum, Horseferry Road, Westminster, London, S.W.1, on Tuesday, March 29, at 6.30 p.m. Tickets (free) may be obtained by persons wishing to attend on application to the secretary of the Industrial Lighting Section of the Illuminating Engineering Society (Mr. C. W. M. Phillips, The British Thomson-Houston Company, Limited, Crown House, Aldwych, London, W.C.2).

THE MACHINERY USERS' ASSOCIATION was formed about fifty years ago, to benefit firms which found themselves faced towards the end of last century with problems arising chiefly from the growing employment of machinery. Up to the present the Association's main activities have been devoted to problems of rating and valuation, but its aim is to include a number of further and similar services, such as technical, economic and legal. Under the first head come improvements and adaptation of machinery to new requirements; machine, factory and building design; operation; patents, etc., while economic questions cover such things as the relation of prime and running costs to overheads; relation of labour costs to running costs; movements of raw-material prices; wage fluctuations; recruitment of technical staff; welfare; credit facilities; statistical and industrial information; and so on. Legal advice covers contracts; patents; compensation; company formation; and numerous other questions of a like nature. The director and secretary is Mr. W. Tudor Davies, 7A, Laurence Pountney Hill, Cannon Street, London, E.C.4.

AN IMPORTANT AGREEMENT has been reached between the National Light Castings Ironfounders' Federation and the Ironfounding Workers' Association and the National Union of Foundry Workers, in regard to the payment to workers for castings spoiled by bad metal. The agreement is minuted in the annual report of the Ironfounding Workers' Association just issued by Mr. Hugh Murdoch, general secretary, Falkirk, and reads as follow:—"Where loss, arising from castings turning out faulty, is incurred by a moulder, who is a member of a trade union, and who considers that such loss is attributable to bad metal, he shall report the matter immediately to his foreman, so that the work may be inspected without delay, and if the latter is satisfied that it has been caused by bad metal, the moulder concerned shall be paid in full for such loss. If, however, the loss is found to be due to any carelessness or faulty workmanship on the part of the moulder, no compensation shall be payable. In the event of the moulder concerned and the foreman failing to agree upon the claim, it shall be submitted at once to two other experienced moulders, who have been nominated by the Union, along with two representatives of the management, who shall determine whether the loss has been caused through bad metal or otherwise, and their decision shall be final." The agreement operates as from November. The agreement is a very important one, as, in recent years, spoiled castings arising from bad metal is alleged to have been the cause of strikes in the Falkirk area. Further in the report, there are minuted other agreements concerning (*a*) payment for overtime work; (*b*) payment for Sunday work; (*c*) payment for work done on public holidays, and (*d*) payment for waiting time. Mr. Murdoch writes that employment among the members was very good during the greater part of last year, but there was a slackening-off towards November and December. The membership stands at 11,880, serving industrial areas in both England and Scotland, and the funds total £39,750 7s. 4d.

Personal

SIR RONALD MATTHEWS, J.P., was on Monday elected deputy chairman of General Refractories, Limited.

MR. E. TODD has been appointed as manager of the Belfast office of J. H. Fenner & Company, Limited, power-transmission engineers, of Hull.

MR. P. SCHWIETZKE, of Düsseldorf, has been elected President of the International Committee of Foundry Technical Associations, and Dr. Guido Vanzetti the Vice-President.

MR. F. R. STAGG, a director of Thos. W. Ward, Limited, Sheffield, since 1927, has been appointed an assistant managing director. He is assistant managing director of The Ketton Portland Cement Company, Limited, and a director of Ribblesdale Cement, Limited; Marshall, Sons & Company (Successors), Limited; Lowmoor Best Yorkshire Iron, Limited, and the Widnes Foundry & Engineering Company, Limited.

MR. CHARLES S. GILL, formerly commercial manager of Davy & United Engineering Company, Limited, Sheffield, has been appointed director and general manager of its subsidiary company, Davy & United Roll Foundry, Limited, Empire Works, Haverton Hill, Billingham, County Durham. Following on Mr. Gill's appointment the Sheffield company will cease to act as sole selling agent of the subsidiary company, the commercial organisation of which will be conducted from Haverton Hill.

Wills

BRAMALL, HENRY, of Sheffield, a director of C. T. Skelton & Company, Limited, steel and implement makers	£2,163
CAPRON, A. J., vice-chairman of Newton, Chambers & Company, Limited, Thorncliffe Ironworks, Sheffield, and for many years managing director of Davy Bros., Limited, engineers, Sheffield	£28,367

Obituary

THE DEATH has occurred of Mr. W. J. Woodcock, aged 60, managing director of W. Woodcock, Sons & Company, Limited, Phœnix Foundry, St. Helens, Lancs.

MR. JOSEPH YOUNGER, of Bardon Mill, Northumberland, who has died at the age of 90, was in active partnership in an ironfoundry business at Dunston-on-Tyne, but retired 30 years ago.

MR. HERBERT CROOKES, a prominent figure in the cutlery trade, being chairman and managing director of Brookes & Crookes, Limited, Sheffield, died on March 9. He was 85 years of age.

MR. PERCY WILLIAM FAWCETT died on March 9, aged 66. Until May last year, when he resigned owing to ill-health, he was managing director of the Park Gate Iron & Steel Company. He was the chief engineer of Thos. Firth & Sons, Limited, Sheffield, from 1897 until 1921. In 1922 he became a director of Firth's, acting as their consulting engineer, and after the amalgamation with John Brown & Company, Limited, he continued as a director of Thos. Firth & John Brown, Limited. Other firms of which he was a director were Brown Bros. & Company, Limited, Cravens Railway Carriage & Wagon Company, Limited, Staveley Coal & Iron Company, Limited, Yorkshire Main Colliery (1923), Limited, Loddington Ironstone Company, Limited, Markham & Company, Limited, and Oughtibridge Silica Firebrick Company, Limited.

Company Reports

Baldwins, Limited.—Dividend of 10 per cent. on the ordinary stock.

Vickers, Limited.—Dividend for 1937 of 10 per cent. on the ordinary stock.

Dunswart Iron & Steel Works, Limited.—Interim dividend of 6 per cent. on the ordinary shares.

Radiation, Limited.—Final dividend of 9⅜ per cent., making 12½ per cent., plus a bonus of 2½ per cent.

Watford Electric & Manufacturing Company, Limited.—Final dividend of 10 per cent., making 15 per cent. for 1937, on the ordinary shares.

Cammell Laird & Company, Limited.—Net profit for 1937, £223,707; brought in, £22,339; dividend of 8⅓ per cent.; to general reserve, £100,000; carried forward, £35,109.

John I. Thornycroft & Company, Limited.—Payment of 18 per cent. on the 6 per cent. cumulative preference shares, being balance of dividend accrued to June 30, 1937.

British Insulated Cables, Limited.—Profit for 1937, £821,358; brought in, £380,879; final dividend on the ordinary shares of 10 per cent., plus a cash bonus of 5 per cent., making 20 per cent.; to reserve, £100,000; depreciation, £143,091; carried forward, £446,992.

Clarke, Chapman & Company, Limited.—Net profit for 1937, after taxation, £92,962; depreciation, £13,609; brought in, £13,207; preference dividend, £4,889; dividend of 10 per cent. on the ordinary shares, £45,656; to reserve account, £20,000; carried forward, £19,889.

Midland Electric Manufacturing Company, Limited.—Net profit for the year ended December 31, £53,770; brought in, £29,174; dividend of 10 per cent. on the ordinary shares for the year, and a bonus of 15 per cent.; to general reserve, £20,000; carried forward, £30,601.

Millom & Askam Hematite Iron Company, Limited.—Profit for 1937, after the debenture service and taxation, £152,704; preference dividend, £27,362; written off fixed assets, £50,000; to blast furnace improvement account, £20,000; to reserve, £50,000; dividend of 10 per cent. on the ordinary shares, £29,243; brought in, £66,241; carried forward, £42,341.

Contracts Open

East Kesteven, March 19.—1,000 yds. of 1-in. galvanised, heavy waterworks pattern, water main, etc., for the Rural District Council. The Engineer, Council Offices, Northgate, Sleaford.

Bedford, March 26.—Supply and setting to work of six Diesel engine driven centrifugal pumps, for the Town Council. The Borough Engineer, Horne Lane, Bedford. (Fee £5. returnable.)

Johannesburg, May 3.—Vertical spindle centrifugal pump for the Rand Water Board. The Department of Overseas Trade. (Reference T.Y.18743/38.)

Pretoria, March 31.—Two vertical discharge centrifugal sewage pumps and two drip-proof ventilated. high starting-torque squirrel-cage motors, for the Public Works Department. The Department of Overseas Trade. (Reference T.Y. 18737/38.)

Forthcoming Events

MARCH 24.

Institute of Fuel:—"Heat-Resisting Steels," Paper by Dr. W. H. Hatfield, at Junior Institution of Engineers, 39, Victoria Street, London, S.W.1, at 6 p.m.

MARCH 25.

Manchester Association of Engineers:—Annual general meeting; "Optical Measuring," Paper by T. Curson, at Engineers' Club, Albert Square, Manchester, at 7.15 p.m.

Institute of British Foundrymen

MARCH 26.

Bristol Section:—Annual meeting; "Patternshop Practice," Paper by T. R. Harris, at Merchant Venturers' Technical College, Bristol, at 7 p.m.

East Midlands Branch:—Annual meeting; summary of session's Papers, by H. L. Sanders, at Loughborough College, Loughborough, at 6 p.m.

Newcastle Branch:—Short Papers, and annual meeting, at Neville Hall, Westgate Road, Newcastle-upon-Tyne, at 6.15 p.m.

The Institute of Vitreous Enamellers

MARCH 24.

Scottish Section:—"Working Properties and Durability of Enamels," Paper by G. M. Logan, at Royal Technical College Society's Rooms, Glasgow, at 7.30 p.m.

MOULDING SANDS *for* THE FOUNDRY

The selection of a moulding medium for the foundry necessitates the utmost care and attention. Higher casting temperatures have resulted in a demand for moulding sands of greater refractoriness and permeability, to withstand these severe conditions. General Refractories, Limited, specialises in sand of this description. There is a great variety of sands and it is important to choose the one to suit your exact requirements. Some are mentioned below, but if you desire more detailed information, the Technical Department is always willing to make recommendations on hearing the conditions of individual problems.

YORKSHIRE MOULDING SAND
for Steel Castings
BRAMCOTE MOULDING SAND
for Iron and Brass Castings
THANET MOULDING SAND
for all kinds of Iron Castings
YORK YELLOW MOULDING SAND
for medium weight Iron Castings
ZENITH MOULDING SAND
for Iron and Brass Castings
MANSFIELD MOULDING SAND
for light Castings
CAVE BROWN MOULDING SAND
for medium size castings in Brass or Iron

Please address enquiries to the nearest Sales Office :

GENERAL REFRACTORIES LTD.

Telephone : *Sheffield* 31113 (6 *lines*). **GENEFAX HOUSE, SHEFFIELD, 10** *Telegrams :* *"Genefax, Sheffield."*

LONDON OFFICE : Russell House, Adam St. Strand, W.C.2. Telephone : Temple Bar 3511. Telegrams : "Genefax, Rand-London." (Mr. A. C. Turner).

SCOTTISH OFFICE : 48, West Regent Street, Glasgow, C.2. Telephone : Douglas 6108. Telegrams : (3 lines). "Genefax, Glasgow." (Mr. C. A. G. Thomson).

SWANSEA OFFICE : Metropole Chambers, Wind Street, Telephone : 3680. Telegrams : "Genefax, Swansea." (Mr. D. F. Hood-Williams).

MANCHESTER OFFICE : 9, Albert Square. Telephone : Blackfriars 6130. Telegrams : "Genefax, Manchester." (Mr. S. G. Throssell).

MIDDLESBROUGH OFFICE : Halifax Bldgs.,Exchange Place, Telephone : Middlesbrough 3313. Telegrams : "Genefax, Middlesbrough." (Mr. J. A. Williams).

CARDIFF OFFICE : 17, Windsor Place, Telephone : 5796. Telegrams : "Genefax, Cardiff." (Mr. F. E. Rutter).

Raw Material Markets

Stocks of foundry iron at the consuming plants continue to increase and are much in excess of actual requirements. Producers are still making heavy deliveries, but, apart from the fact that users are less active than they were, they are also receiving substantial imports which were arranged for when the supply position in this country was unsatisfactory. No doubt imports are being despatched as quickly as possible, as it is anticipated that the Import Duties Advisory Committee will re-impose the tariff on pig-iron in the near future. The heavy steel works continue to be very well employed.

Pig-Iron

MIDDLESBROUGH.—Producers are experiencing great difficulty in disposing of their outputs and they are having to put heavy tonnages into stock, as the consumers are also overloaded with iron. Much of this was bought on the Continent and in the Midlands, when supplies of locally-produced iron were short. Scottish consumers, who would have been only too willing to take up iron from this area during last year, are now finding that they, too, are overstocked and cannot accept full contract deliveries from their own makers. For delivery to the Middlesbrough or Falkirk districts, No. 3 Cleveland G.M.B. foundry iron is quoted at 109s. per ton, No. 1 foundry at 111s. 6d., and No. 4 foundry and No. 4 forge at 108s., all less 5s. per ton rebate.

New business in hematite is restricted to hand-to-mouth buying and only small tonnages are involved. Quite good deliveries are still being made to consumers, but there is no doubt that a quieter tone has come over the market. For delivery on the North-East Coast, mixed numbers of hematite are quoted at 132s. 6d., 138s. in Sheffield, and 143s. 6d. in the Midlands, all less 5s. rebate.

LANCASHIRE.—With the exception of textile machinists and light-castings founders, consumers in this area are fairly well employed, although there are occasional indications that trade is on the decline. Consumers are well covered for their requirements and in many cases substantial tonnages are being put to reserve. New business in hematite is quiet. For delivery to users in the Lancashire price zone, Derbyshire and Lancashire brands of No. 3 pig-iron are quoted on the basis of 114s. per ton, with Northamptonshire at 112s. 6d., and Derbyshire forge iron at from 111s. to 113s., according to the class of consumer. West Coast hematite is at 141s. and East Coast at 140s. 6d.

MIDLANDS.—Owing to the heavy costs of maintaining stocks at their present proportions, some producers are considering damping down furnaces. This has already been done in some cases, in fact. Being well supplied, consumers are not entering into further business. Machine-tool makers continue to take up good tonnages of low-phosphoric iron, but there has been a decline in the requirements of some other users of this material. For delivery to Birmingham and Black Country stations, Northamptonshire No. 3 is quoted at £5 8s. 6d., with Derbyshire No. 3 at £5 11s. Low-phosphorus iron varies from £6 5s. to £7 7s. 6d., while refined iron is at a minimum of £8 5s. per ton. A more attractive quotation for the latter, may, however, be obtained from makers not in the Association. The hematite market has further eased, supplies being more plentiful, while the demand has slackened. East Coast No. 3 is quoted at £7 3s. 6d., with West Coast mixed numbers at £7 4s. 6d., delivered to Birmingham and district and less 5s. rebate.

SCOTLAND.—The consumption of hematite and basic in this area is maintained on a good scale, but the demand for foundry iron is very subdued. Consumers' depôts are being still further congested by the arrival of heavy tonnages from the Continent, as it is desired that as much iron as possible enters the country before the expected reimposition of the tariff. Local steelworks are working to capacity and they are well supplied with pig-iron.

Coke

Although foundry coke producers have stated that no change will be made in prices before the end of the year, consumers are not anxious to purchase supplies for delivery ahead, as they are confident that makers will reconsider their decision when the customary summer quietness sets in. For delivery to Birmingham and district, best Durham foundry coke is quoted at a minimum of 55s. 9d., with Welsh coke at from 55s. to 62s. 6d. per ton.

Steel

Production is proceeding at a high rate in the steel industry, but the volume of new business is restricted, and inactive conditions rule in the market. In several departments the anxiety of foreign suppliers to deliver steel ordered when it was difficult to obtain British supplies has led to severe congestion. Large quantities of semi-finished steel have arrived in this country of late, and most of the works are having more delivered to them than is convenient. As a result, there is a lull in fresh buying, which may last until consumers have reduced their stocks. The demand for finished steel has declined somewhat of late, but the requirements of users are still large, and the heavy branches of the industry, in particular, are well employed. Owing to the quietness of new business, arrears in deliveries are being worked off, but a considerable tonnage of orders remains on the books.

Scrap

The demand for iron scrap has fallen away considerably of late and ample supplies are now available for prompt business. There is still a fair tonnage of steel scrap being taken up, but this section also appears to have taken a quieter turn. In many cases, steelworks have supplies in stock.

Metals

Despite the disturbed political conditions during the past week, there has been quite a firm tone in non-ferrous metals. The publication of the world copper statistics had a stimulating effect.

Copper.—World stocks of refined copper during February increased by 23,890 tons to 529,850 tons. The apparent world consumption totalled 137,000 tons. The world output by mines and smelters reached 153,000 tons. World production of refined copper totalled 161,000 tons. These results were much more favourable than had been anticipated. The weekly market report issued by Rudolf Wolff & Company, states that the steadiness of the market is its chief characteristic, for while the unsettled outlook and a certain lack of confidence exert a restricting influence on buyers, the market is undoubtedly displaying a good deal of resistance at around current levels. Consumption, apart from the United States, is reported to be well maintained, and a substantial tonnage is in process of being shipped to Russia and Japan against the large purchases recently made for their account. Steady conditions seem likely to prevail until such time as the outlook clears, or some fresh feature arises which might have a stimulating effect on confidence.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £39 18s. 9d. to £40 1s. 3d.; Friday, £39 6s. 3d. to £39 7s. 6d.; Monday, £40 3s. 9d. to £40 5s.; Tuesday, £41 5s. to £41 7s. 6d.; Wednesday, £40 15s. to £40 17s. 6d.

Three Months.—Thursday, £40 2s. 6d. to £40 3s. 9d.; Friday, £39 10s. to £39 12s. 6d.; Monday, £40 7s. 6d. to £40 8s. 9d.; Tuesday, £41 10s. to £41 12s. 6d.; Wednesday, £41 to £41 2s. 6d.

Tin.—It is understood that details of the Malayan bonded tin pooling scheme stipulate that rights to produce extra tin must not be transferred or sold as quota rights are at present sold. Also, no certificates of production will be issuable to mines not working, even though they are eligible for the ordinary quotas. The official statement reiterates that the scheme is intended to ease the labour situation and provides that the smelters—the Eastern Smelting Company and the Straits Trading Company—which will hold the tin in bond will, if desired, advance funds to producers. Therefore, at present, there is no question of the Government financing the scheme. It is generally thought that the scheme is not likely to meet with any opposition from Dutch tin circles. While it is realised that technically the measure involves a violation of the restriction scheme, which prescribes that production must be in the region of the quota, it is believed that the International Tin Committee will raise no objection, as the extra quantity will be absorbed within a year.

It is reported that the discussions regarding the sale of tin from the Netherlands East Indies to Japan have been broken off, as the Japanese Government is not prepared to furnish the necessary exchange.

At a meeting of the Council of the Tin Producers' Association held in London on Monday, the proposed buffer stock scheme, and the recent reduction of the export quota for the second quarter were considered. The Council registered its unanimous approval of a draft buffer stock scheme. It decided to urge the Secretary of State for the Colonies and the International Tin Committee to put the scheme into operation at as early a date as possible. The Council unanimously agreed that in view of the serious decline in the demand for tin since the middle of last year, the International Tin Committee was completely justified in making a reduction in the quota of production.

Official quotations were as follow :—

Cash.—Thursday, £185 15s. to £186; Friday, £182 10s. to £182 15s.; Monday, £182 15s. to £183; Tuesday, £186 15s. to £187; Wednesday, £185 to £185 5s.

Three Months.—Thursday, £185 10s. to £186; Friday, £182 10s. to £182 15s.; Monday, £182 15s. to £183; Tuesday, £187 to £187 10s.; Wednesday, £185 5s. to £185 10s.

Spelter.—Little business is being negotiated at the present time and the market remains very quiet. No change is reported in the dull tone of the American market.

Daily market prices :—

Ordinary.—Thursday, £14 3s. 9d.; Friday, £14; Monday, £14 5s.; Tuesday, £15 1s. 3d.; Wednesday, £15 3s. 9d.

Lead.—Business has continued to be small, although quite a good tone is ruling. There are no signs of any early change in the attitude of consumers towards new contracts.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £15 7s. 6d.; Friday, £15 5s.; Monday, £15 13s. 9d.; Tuesday, £16 17s. 6d.; Wednesday, £16 8s. 9d.

Scrap.—No serious trading is being conducted at the present time and only small tonnages have been involved in recent transactions. Further price reductions have been made during the past week.

Approximate selling prices for old metal:—New aluminium cuttings, £80; rolled, £63; cast, £38; foil, £88. Copper, £37 to £39; braziery, £33 to £34. Brass (clean), £23 to £25. Zinc, £7 10s. Lead, £12 10s. Gunmetal, £37 to £39.

New Zealand Iron and Steel Industry

PROPOSED STATE ENTERPRISE

Legislation has been introduced into the New Zealand House of Representatives which will empower the Government to establish an iron and steel industry. It is proposed to undertake the mining of ore and smelting at Onekaka, in Nelson Province, where operations were previously undertaken by a private company. The Bill now vests in the Crown the sole rights of mining ore in New Zealand, and empowers the Government to borrow £5,000,000 to establish the industry under the control of three commissioners. The works authorised include mining, smelting, and ancillary operations such as coal mining and shipping. The mining privileges held by the existing Onekaka Company will be revoked, and provision made for the payment of compensation.

Mr. Sullivan, the Minister of Industries and Commerce, explaining the proposals, said the industry would employ 1,200 men and 300 more in ancillary industries. The proposals were based on a report by Brassert & Company, of London, who advised the Government that the scheme submitted would enable the industry to be established on an economic basis. The Government proposed to ask Messrs. Brassert to undertake the technical supervision in the initial stages. New Zealand consumed 100,000 tons of sheet, bar, and wire products annually, besides rails, pig-iron, and steel in the smaller sections, and the initial production of the plant would be 85,000 tons annually. The Government did not intend to attempt the manufacture of the heavier steel sections or ship's plates for some years, and would still require to import about 75,000 tons, which could not be economically produced. It would be unnecessary to charge higher prices for the products of the proposed State industry. If, however, the Government were faced with dumping or unfair competition, it would be their duty to protect such an important undertaking; but it appeared that the industry could stand on its own feet, and the Government saw no reason why an understanding should not be had with the British Iron and Steel Federation.

BE WISE — BUY WISE

BUY BRITISH!

Buy PRECISION CHAPLETS & STUDS

AND BE SURE OF GETTING THE BEST. PRECISION PERFORATED CHAPLETS: all shapes, sizes and thicknesses

PRECISION STUDS FOR LIGHT AND HEAVY CASTINGS

●

Also Makers of:—Door Catches • Hinge Tubes and Dovetails for the General Stove and Range Trades • Skimming Gates, Radiator, Nail, Top Hat and every type of Chaplet used in the General Foundry

Remember!

PRECISION CHAPLETS and STUDS FOR BETTER RESULTS

Stockists:
A. LAKIN & SON
TOTLEY RISE,
SHEFFIELD
Phone: Beauchief 70421

PRECISION PRESSWORK CO.

PATENTEES
CLIMAX WORKS, COLESHILL STREET
BIRMINGHAM 4.

Scottish Representative:
GEO. SMART
59, LUBNAIG ROAD,
GLASGOW, S.3
Phone: Merrylee 3120

Phone: ASTON CROSS 1402 **ESTB. 1874** Grams: "Precico, Phone, Birmingham"

WARNER *Special* PIG IRONS

- *Warner C.B.R.*
  and
- *Low Carbon Cylinder*
  (FOR CYLINDERS, ROLLS, ENGINEERING CASTINGS, ETC.)
- *Low Carbon Malleable*
  (FOR MALLEABLE CASTINGS OF ALL DESCRIPTIONS)

Supplied to any specification between limits of 2·00 and 3·50% Carbon and ·50% and 3·50% Silicon

●

ACTUAL ANALYSIS CERTIFICATES ARE AVAILABLE WITH EACH DELIVERY

● **Typical Cylinder Pig Iron Specification**

TOTAL CARBON	2·70%
SILICON	1·80%
MANGANESE	·90%
SULPHUR	·06%
PHOSPHORUS	·40%

● **Typical Malleable Pig Iron Specification**

TOTAL CARBON	2·60%
SILICON	·75%
MANGANESE	·50%
SULPHUR	·05%
PHOSPHORUS	·06%

WARNER & CO., LTD.
CARGO FLEET · MIDDLESBROUGH

RAW MATERIALS—PRICE LIST

(Wednesday, March 16, 1938)

COPPER

	£	s.	d.
Standard cash	40	15	0
Three months	41	0	0
Electrolytic	44	10	0
Tough	43	5	0
Best selected	43	15	0
Sheets	74	10	0
India	56	7	6
Wire bars	45	0	0
Ingot bars	45	0	0
H.C. Wire rods	48	10	0
Off., av. cash, Feb.	39	12	10½
Do., 3 mths., Feb.	39	17	1⅞
Do., Sttlmnt., Feb.	39	13	0
Do., Electro, Feb.	43	19	2½
Do., B.S., Feb.	43	10	7½
Do., Wire bars, Feb.	44	7	1½
Solid drawn tubes			12½d.
Brazed tubes			12½d.
Wire			8¼d.

BRASS

Solid drawn tubes	11½d.
Brazed tubes	13½d.
Rods, drawn	9d.
Rods, extd. or rlld.	6½d.
Sheets to 10 w.g.	8½d.
Wire	8½d.
Rolled metal	7¾d.
Yellow metal rods	6¼d.

TIN

	£	s.	d.
Standard cash	185	0	0
Three months	185	5	0
English	185	0	0
Bars	187	0	0
Straits	186	10	0
Eastern	188	0	0
Banca (nom.)			—
Off. av. cash, Feb.	183	5	3½
Do., 3 mths., Feb.	183	2	9½
Do., Sttlmt., Feb.	183	4	6

SPELTER

	£	s.	d.
Ordinary	15	3	9
Remelted	12	5	0
Hard	12	0	0
Electro, 99.9	19	1	3
English	16	5	0
India	14	5	0
Zinc dust	21	0	0
Zinc ashes	5	10	0
Off. aver., Feb.	14	9	11½
Aver., spot, Feb.	14	8	1⅞

LEAD

	£	s.	d.
Soft foreign, ppt.	16	8	9
Empire (nom.)	17	13	9
English	18	10	0
Sheets, home	23	0	0
Do. export	19	5	0
Pipes, home	22	10	0
Do. export	19	17	6
Tea lead	31	15	0
Off. aver., Feb.	15	9	3 3/16
Aver., spot, Feb.	15	8	0⅜

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£	s.	d.		£	s.	d.
Zinc sheets, English	29	10	0	to	29	15	0
Do., V.M. ex-whse.	29	10	0	to	29	15	0
Rods			21	10	0		

ANTIMONY

	£	s.	d.		£	s.	d.
English	81	0	0	to	82	0	0
Chinese, ex-whse.			67	0	0		
Crude, c.i.f.			40	0	0		

QUICKSILVER

	£	s.	d.
Quicksilver	12	5	0

FERRO-ALLOYS AND STEEL-MAKING METALS

	£	s.	d.
Ferro-silicon—			
25%	12	10	0
45/50%	12	0	0
75%	17	0	0
Ferro-vanadium—			
35/50%	14/- lb. Va.		
Ferro-molybdenum—			
70/75% carbon-free	4/9 lb. Mo.		
Ferro-titanium—			
20/25% carbon-free	9d. lb.		
Ferro-phosphorus, 20/25%	£21 to £22		
Ferro-tungsten—			
80/85%	6/- lb. (nom.)		
Tungsten metal powder—			
98/99%	6/1½ lb. (nom.)		
Ferro-chrome—			
2/4% car.	34	15	0
4/6% car.	24	5	0
6/8% car.	24	0	0
8/10% car.	24	0	0
Ferro-chrome—			
Max. 2% car.	36	0	0
Max. 1% car.	38	5	0
Max. 0.5% car.	41	0	0
70% carbon-free	10d. lb.		
Nickel—99.5/100%	£180 to £185		
"F" nickel shot	£165	0	0
Ferro-cobalt, 98/99%	8/6 to 8/9 lb.		
Metallic chromium—			
96/98%	2/5 lb.		
Ferro-manganese—			
76/80% loose	£18 15 0 to 19	5	0
76/80% packed	£19 15 0 to 20	5	0
76/80% export	£22	0	0
Metallic manganese—			
94/96% carbon-free	1/3 lb.		

Per ton unless otherwise stated, basis 2-ton lots.

SCRAP

	£	s.	d.		£	s.	d.
South Wales (West)—							
Heavy steel, best	3	8	9	to 3	11	3	
Mixed iron and steel	3	6	9	to 3	9	3	
Heavy cast iron	3	8	9	to 3	11	3	
Good machinery	3	12	6	to 3	15	0	
Cleveland—							
Heavy steel, best	3	7	0	to 3	9	6	
Steel turnings	2	13	0	to 2	15	6	
Heavy cast iron				to 4	0	0	
Heavy machinery				to 4	5	0	
Midlands—							
Short heavy steel				to 3	15	0	
Light cast-iron scrap				to 3	2	6	
Heavy wrought iron	4	0	0	to 4	5	0	
Steel turnings	2	6	3	to 2	8	9	
Scotland—							
Heavy steel, best	3	5	0	to 3	7	6	
Ordinary cast iron	4	0	0	to 4	2	6	
Cast-iron borings	2	0	6	to 2	3	0	
Wrot-iron piling	4	5	0	to 4	7	6	
Heavy machinery				to 4	10	0	

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	32	0	0
Brass	22	10	0
Lead (less usual draft)	13	10	0
Tea lead	10	10	0
Zinc	7	0	0
New aluminium cuttings	70	0	0
Braziery copper	29	0	0
Gunmetal	32	0	0
Hollow pewter	130	0	0
Shaped black pewter	90	0	0

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	3s. 6d.
Finished bars, 18% tungsten	4s. 6d.

Per lb. d/d buyers' works.

PIG-IRON*

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	111/6
,, No. 3	109/-
,, No. 4	108/-
Forge No. 4	108/-
Hematite No. 1	133/-
Hematite M/Nos.	132/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	133/-
,, d/d Birm.	144/6
Malleable iron d/d Birm.	165/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	110/-
,, No. 3 fdry.	111/-
Northants forge	107/6
,, fdry. No. 3	108/6
,, fdry. No. 1	111/6
Derbyshire forge	110/-
,, fdry. No. 3	111/-
,, fdry. No. 1	114/-
Scotland—	
Foundry, No. 1, f.o.t.	120/6
,, No. 3, f.o.t.	118/-
Cleveland No. 3, Glasgow	112/-
,, ,, Falkirk	109/-
Scottish hem. M/Nos. d/d	133/-
Sheffield (d/d district)—	
Derby forge	107/6
,, fdry. No. 3	108/6
Lincs forge	107/6
,, fdry. No. 3	108/6
W.C. hematite	138/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	114/-
Staffs fdry. No. 3	114/-
Northants fdry. No. 3	112/6
Cleveland fdry. No. 3	114/-
Glengarnock, No. 3	141/-
Clyde, No. 3	141/-
Monkland, No. 3	141/-
Eglinton, No. 3	141/-
Gartsherrie, No. 3	141/-
Shotts, No. 3	141/-

(* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.)

FINISHED IRON AND STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

Iron—	£	s.	d.		£	s.	d.
Bars (cr.)	13	5	0	to 13	15	0	
Nut and bolt iron	11	12	6	to 12	2	6	
Hoops				14	2	6	
Marked bars (Staffs) f.o.t.				15	15	0	
Gas strip				14	2	6	
Bolts and nuts, ¾ in. × 4 in.				17	10	0 and up	
Steel—							
Plates, ship, etc.	11	8	0	to 11	10	6	
Boiler plts.	11	18	0	to 12	0	6	
Chequer plts.				13	0	6	
Angles				11	0	6	
Tees				12	0	6	
Joists				11	0	6	
Rounds and squares, 3 in. to 5¼ in.				12	0	6	
Rounds under 3 in. to ¾ in. (untested)				11	9	0	
Flats—8 in. wide and over				11	5	6	
,, under 8 in. and over 5 in.				11	10	6	
Rails, heavy				10	2	6	
Fishplates				14	2	6	
Hoops (Staffs)				12	4	0	
Black sheets, 24g. (4-t. lots)				15	15	0	
Galv. cor. shts. (,,)				18	10	0	
Galv. flat shts. (,,)				19	0	0	
Galv. fencing wire, 8g. plain				20	5	0	
Billets, soft, 100-ton lots				7	17	6	
Sheet bars				7	15	0	
Tin bars				7	15	0	

PHOSPHOR BRONZE

	Per lb. basis
Strip	10¾d.
Sheet to 10 w.g.	11¼d.
Wire	12¾d.
Rods	13¼d.
Tubes	18¼d.
Castings	15d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop. £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	8d. to 1/2
Rolled—	
To 9 in. wide	1/2 to 1/8
To 12 in. wide	1/2¼ to 1/8½
To 15 in. wide	1/2½ to 1/8¾
To 18 in. wide	1/3 to 1/9
To 21 in. wide	1/3½ to 1/9½
To 25 in. wide	1/4 to 1/10
Ingots for spoons and forks	8d. to 1/4½
Ingots rolled to spoon size	11d. to 1/7½
Wire round—	
to 10g.	1/5½ to 2/0½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/4½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.84
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	102.50
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.25
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	3.15
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb. box	$5.35

COKE (at ovens)

Welsh foundry	42/6
,, furnace	37/6
Durham foundry	39/6
,, furnace	32/6
Scottish foundry	41/6
,, furnace	40/-

TINPLATES

f.o.b. British Channel ports.

I.C. cokes	20×14 per box		22/6
,,	28×20 ,,		45/-
,,	20×10 ,,		34/9
,,	18¾×14 ,,		24/9
C.W.	20×14 ,,		17/9 to 18/6
,,	28×20 ,,		35/6 to 37/-
,,	20×10 ,,		29/3 to 29/9
,,	18¾×14 ,,		20/9 to 21/3

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.		£	s.	d.
Pig-iron	£12	0	0	to £13	0	0	
Bars-hammered, basis	£20	0	0	to £22	0	0	
Bars and nail-rods, rolled, basis	£19	0	0	to £20	0	0	
Blooms	£18	0	0	to £19	0	0	
Keg steel	£30	0	0	to £35	0	0	
Faggot steel	£20	0	0	to £25	0	0	
Bars and rods dead soft st'l	£19	0	0	to £20	0	0	

All per English ton, f.o.b. Gothenburg [Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£	s.	d.		
Mar. 10 ..	39	18	9	inc.	1/3
„ 11 ..	39	6	3	dec.	12/6
„ 14 ..	40	3	9	inc.	17/6
„ 15 ..	41	5	0	„	21/3
„ 16 ..	40	15	0	dec.	10/–

Electrolytic Copper

	£	s.	d.		
Mar. 10 ..	43	15	0	inc.	2/6
„ 11 ..	43	0	0	dec.	15/–
„ 14 ..	43	10	0	inc.	10/–
„ 15 ..	44	10	0	„	20/–
„ 16 ..	44	10	0	No	change

Standard Tin (cash)

	£	s.	d.		
Mar. 10 ..	185	15	0	dec.	2/6
„ 11 ..	182	10	0	„	65/–
„ 14 ..	182	15	0	inc.	5/–
„ 15 ..	186	15	0	„	80/–
„ 16 ..	185	0	0	dec.	35/–

Tin (English ingots)

	£	s.	d.		
Mar. 10 ..	185	15	0	dec.	2/6
„ 11 ..	182	10	0	„	65/–
„ 14 ..	182	15	0	inc.	5/–
„ 15 ..	186	15	0	„	80/–
„ 16 ..	185	0	0	dec.	35/–

Spelter (ordinary)

	£	s.	d.		
Mar. 10 ..	14	3	9	No	change
„ 11 ..	14	0	0	dec.	3/9
„ 14 ..	14	5	0	inc.	5/–
„ 15 ..	15	1	3	„	16/3
„ 16 ..	15	3	9	„	2/6

Spelter (Electro, 99.9 per cent.)

	£	s.	d.		
Mar. 10 ..	18	1	3	dec.	1/3
„ 11 ..	17	16	3	„	5/–
„ 14 ..	18	1	3	inc.	5/–
„ 15 ..	18	18	9	„	17/6
„ 16 ..	19	1	3	„	2/6

Lead (soft foreign, prompt)

	£	s.	d.		
Mar. 10 ..	15	7	6	dec.	2/6
„ 11 ..	15	5	0	„	2/6
„ 14 ..	15	13	9	inc.	8/9
„ 15 ..	16	17	6	„	23/9
„ 16 ..	16	8	9	dec.	8/9

Lead (English)

	£	s.	d.		
Mar. 10 ..	17	10	0	No	change
„ 11 ..	17	5	0	dec.	5/–
„ 14 ..	17	15	0	inc.	10/–
„ 15 ..	19	0	0	„	25/–
„ 16 ..	18	10	0	dec.	10/–

Imports and Exports of Pig-iron, Castings, etc., in February and the Two Months 1938, compared with February and the Two Months 1937

	February.		Two months.		February.		Two months.	
	1937.	1938.	1937.	1938.	1937.	1938.	1937.	1938.
	Tons.	Tons.	Tons.	Tons.	£	£	£	£
Imports.								
Pig-iron—from British India	13,967	25,774	25,552	56,046	46,257	129,142	84,242	282,169
„ „ Other British Countries	5,070	—	5,070	—	21,167	—	21,167	—
„ „ Foreign Countries	1,846	50,717	4,806	105,775	11,339	262,520	29,739	569,252
Total	20,883	76,491	35,428	161,821	78,763	391,662	135,148	851,421
Castings and forgings	140	425	613	909	4,827	17,077	16,124	32,758
Cast pipes and fittings	124	126	287	205	2,617	3,718	5,912	6,038
Stoves, grates, etc.	48	76	136	127	7,380	6,651	12,237	11,433
Baths	589	613	1,245	1,115	13,763	15,273	29,353	28,270
Hollow-ware, all kinds	280	234	561	631	16,473	15,160	33,283	38,730
Exports.								
Pig-iron, forge and foundry	6,214	4,169	14,287	12,572	30,724	29,051	65,521	90,531
„ acid	6,223	3,330	11,192	6,442	29,380	27,618	50,958	50,794
„ basic	281	—	281	5	1,485	—	1,485	40
Total	12,718	7,499	25,760	19,019	61,589	56,669	117,964	141,365
Castings and forgings	304	121	677	302	10,786	5,482	24,251	14,833
Cast pipes and fittings, up to 6 in. diameter	4,208	3,084	8,001	9,787	45,087	43,155	88,439	116,852
„ „ over 6 in. „	2,774	4,326	5,268	13,156	23,057	48,959	42,977	132,733
Stoves, grates, etc.	960	692	1,870	1,441	52,880	40,110	100,089	82,807
Sanitary cisterns	264	199	558	470	8,255	7,923	17,552	18,232
Bedsteads, including tubes therefor	428	137	847	359	15,417	6,761	31,259	16,378
Hollow-ware	509	231	883	596	16,464	10,143	29,744	23,530

WILLIAM JACKS & COMPANY,
WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.
CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.
13, RUMFORD STREET, LIVERPOOL.
PIG IRON
REGISTERED TRADE MARK
LUMPEX
FOR EVERY TYPE OF CASTING
NON-FERROUS METALS
REFRACTORIES — COKE — SAND
FERRO-SILICON—FERRO-CHROME
WILLIAM JACKS & COMPANY,
CENTRAL CHAMBERS, 93, HOPE ST., GLASGOW, C.2.
ZETLAND ROAD, MIDDLESBROUGH.

Notice

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 6 words per line. Minimum charge for one insertion 3/-

(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

A LIVE MAN, 20 years in charge of Foundry & Allied Industries, requires position of responsibility; special knowledge of light castings and also experience in enamelling, etc.; energetic organiser. Disengaged.—Please reply to: Box 818, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY FOREMAN requires position in or near London preferred. Capable of taking charge of ferrous and non-ferrous foundries. Modern methods. Any class work and size of casting to capacity of foundry. Well up in cupola practice, moulding machines, loam, green and dry sand work. Tilting furnaces reverberatory furnaces, alloying and pyrometry.—Box 840, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

MANAGER of Engineering Concern desires change. London district preferred. Would consider investing in progressive non-ferrous foundry; 25 years' experience in this and allied trades.—Apply Box 842, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY FOREMAN required for large Non-ferrous Foundry producing castings up to 3 tons. Must be thoroughly experienced in casting various alloys for floor and loam moulding. Excellent prospects for the right man. Only first-class man need apply. Full particulars in first instance to: Box 828, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

REPRESENTATIVE for the sale of Pig-iron. Must be resident in the Midlands. Give full details of experience, age, etc., to: Box 834, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

SPECIAL Pig-iron Representative wanted for Yorkshire and the North. One with good connection among foundries preferred.—Apply Box 836, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WORKING FOREMAN required to take charge of a small iron foundry in Bedfordshire. General jobbing and machines. Castings up to 30 cwts. Good opening for experienced man. Give age and full details of experience.—Box 838, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

FOUNDRY MANAGER, age 40, requires position. Experience in marine engineering, machine tools and general jobbing foundry. Several years' supervisory experience, capable of taking full charge of important engineering foundry. (320)

BUSINESS FOR SALE

FOR immediate disposal. Foundry in Midlands. Equipped for machine moulding. Buildings approx. 5,000 ft. Ample area for extension to canal-side included.—Write Box 844, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

MACHINERY

FOR SALE.—Two Zimmermann R.P.W.2 Pneumatic Jolt Squeeze Turnover Moulding Machines.—S. C. BILSBY, Crosswells Road, Langley Green, near Birmingham.

SAND MIXERS AND AERATORS.—The "Breakir" Centrifugal Machine is *THE* machine. Outputs 10 cwts. to 8 tons per hr.—W. BREALEY & Co., LTD., Station Works, Ecclesfield, Sheffield.

NEW Dwarf Cupola, to melt 10 to 15 cwts. per hr. New Worm-geared Ladles, 5 tons, 25 cwts., 15 cwts. and 10 cwts. capacity. Ungeared Ladles, 15 cwts. and 10 cwts. capacity. Improved Cupola Spark Arresters.—T. DAVIES & SON, West Gorton, Manchester.

'Phone **98** Staines

35/38-H.P. Crossley Horizontal Diesel Oil Engine, new 1932.

2½- and 1½-ton Morris Overhead Hand Cranes.

Tilghman Vertical Belt-driven Air Compressor, 130 c.f. at 100 lbs. w.p.

Riveted Steel Air Receiver, 20 ft. long, 3 ft. dia., 100 lbs. w.p.

Ditto, 6 ft. 6 in. by 2 ft. 6 in., 100 lbs. w.p.

Sand or Paste Mixer, twin Z blades, pan 30 in. by 30 in. by 23 in.

HARRY H. GARDAM & CO., LTD., STAINES.

SANDBLAST PLANTS.

ROOMS size, 12 ft. by 12 ft., 12 ft. by 9 ft., and 6 ft. by 6 ft.

Barrels: 54 in. by 36 in.; 36 in. by 30 in.; 30 in. by 20 in., etc.

Cabinet: 6 ft. by 4 ft.; 4 ft. 6 in. sq. by 3 ft. 6 in. sq., and 30 in. dia.

Table: 9-ft. Guttman.

Air Compressors in stock to suit any of the above plants.

Sand Mills: 7 ft. 6 in., 7 ft., 6 ft., 5 ft. and 4 ft. dia. pans.

Cupolettes: 10 cwts., 15 cwts. and 20 cwts.

Cupolas: 2 and 3 tons.

Morgan Tilting Furnaces: 250 and 400 lbs.

Heavy D.E. Grinding Machine: wheels 24 in. by 4½ in.

Sand Rammers, Disintegrators and Mixers. Air Compressors, Blowers and Exhaust Fans. Moulding Machines, etc., etc.

S. C. BILSBY, A.M.I.C.E., A.M.I.E.E.
CROSSWELLS ROAD (Adjoining Railway Crossing), LANGLEY, Nr. Birmingham.
'Phone: Broadwell 1359.

THOS. W. WARD LTD.

Three LANCS. BOILERS, 28′ long x 7′ 3″ dia.; Hotchkiss Circulators; last insured at 160 lbs. per sq. in. w.p.; built 1920.

LANCS. BOILER, 30′ x 8′ 6″ dia.; built 1917; reinsurable w.p. 150 lbs.

COCHRAN BOILER, 8′ x 3′ 9″; w.p. 100 lbs.

"Economic" type BOILER, 9′ long x 6′ dia.; 120 lbs. w.p.

Write for "Albion" Catalogue.

ALBION WORKS, SHEFFIELD.

'Grams: "Forward." 'Phone: 23001 (10 lines).

MISCELLANEOUS

PATTERNS.—Cleghorn & Co. have new premises at 198-200, Bath Road, Worcester, and are in a better position to cope with all classes of engineers' pattern. 'Phone 264.

MISCELLANEOUS—*Continued*

FOUNDRY Floor Sand. 50 tons free for cost of loading and carting away.—RODNEY FOUNDRY CO., LTD., Deptford Green, London, S.E.8. 'Phone: Tideway 2608.

PLUMBAGO—Our different grades will serve you well and prices are right. Our STANDARD Nos. 1 and 2 at 18s. and 16s. cwt., carriage paid, have a large sale. TRY IT and save money.—WM. OLSEN, LTD., Hull.

'Phone: 287 SLOUGH

30″ Aluminium Cutting Bandsaw, Price £12

JACKMAN Core Stove ... Price £14

"AJAX" 36″×24″ jolt turnover and pattern-draw moulding machines. (Two in stock) ..... Price £60 each

Two good TABOR 14″ × 16″ squeeze and pattern-draw moulding machines ..... Price £35 each

Foundry Travelling Crane, 2-tons, 30 ft. span ..... Price £35

Good small enclosed Rumbler Price £14

New Small 3′ Sandblast Plant.

ALEX. HAMMOND, *Foundry Machinery Merchant,*
14, AUSTRALIA ROAD, SLOUGH
BUY FROM ME AND SAVE MONEY!

IN STOCK

TILGHMAN RECONDITIONED SHOT OR SAND BLAST PLANTS

Rooms, Barrels, & Chambers.

WE SHOT AND SAND BLAST FOR ALL TRADES

Established Fifty Years.

R. J. RICHARDSON & SONS, LTD.,
Commercial Street, Birmingham, 1.
Phone: MIDLAND 2281
Grams: "SANDBLAST, B'HAM"

Ryland's Directory

(2,500 pages 8¼″ × 5¼″)

♦ ♦ ♦

The standard work of reference covering the Coal, Iron, Steel, Tinplate, Metal, Engineering, Hardware and Allied Trades

♦ ♦ ♦

1938 EDITION

Price 42/- Cloth, 52/- Leather

♦ ♦ ♦

INDUSTRIAL NEWSPAPERS Ltd.
49, Wellington St., Strand, London, W.C.2
Telephone: Temple Bar 3951 (5 lines)